016117-1-F

NASA CR-

THE UNIVERSITY OF MICHIGAN

COLLEGE OF ENGINEERING
Department of Atmospheric and Oceanic Science
Space Physics Research Laboratory

DESIGN STUDY FOR ELECTRONIC SYSTEM FOR JUPITER ORBITER PROBE (JOP)

(NASA-CR-160021) DESIGN STUDY FOR ELECTRONIC SYSTEM FOR JUPITER ORBIT PROBE (JOP) Final Report, 14 Feb. - 30 Sep. 1978 (Michigan Univ.) 115 p HC A06/MF A01 CSCL 22B G3/15

N80-31428

Unclas 32503

Prepared on behalf of the project by:

B. P. Elero, Jr.

G. R. Carignan

Under Contract with:

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GODDARD SPACE FLIGHT CENTER
CONTRACT No. NAS5-24454
GREENBELT, MARYLAND 20771

ADMINISTERED THROUGH:

DIVISION OF RESEARCH ADMINISTRATION AND DEVELOPMENT

THE UNIVERSITY OF MICHIGAN 1817

September 30, 1978

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1. INTRODUCTION

During the period between 14 February, 1978 and 30 September 1978, the University of Michigan, Space Physics Research Laboratory was funded under Contract NAS5-24454 to perform a design study of an electronic system for the Jupiter Probe mass spectrometer. A continuation of this activity has been funded under Contract NAS5-25153 and a separate Contract, NAS5-25145, has been negotiated for the procurement of non-hybrid electronic parts for the system.

The activity under this contract conforms exactly with the statement of work and the product of the activity is a preliminary design of electronic system for the Jupiter Probe Mass Spectrometer. Because the design activity is continuing, this final report for Contract NAS5-24454 is an interim report for the complete task and attempts to document the state of the design as of 30 September, 1978.

The attached drawings, parts lists and design notes represent the state of the design as of 30 September, 1978 and implicitly constitute recommendations for the choice of design variables.

2. DRAWINGS

LIST OF DRAWINGS

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LIST OF DRAWINGS (Continued)

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7.12 Control Outputs-1

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8.2 I S Drive Circuits

8.3 I S Drive Blocks

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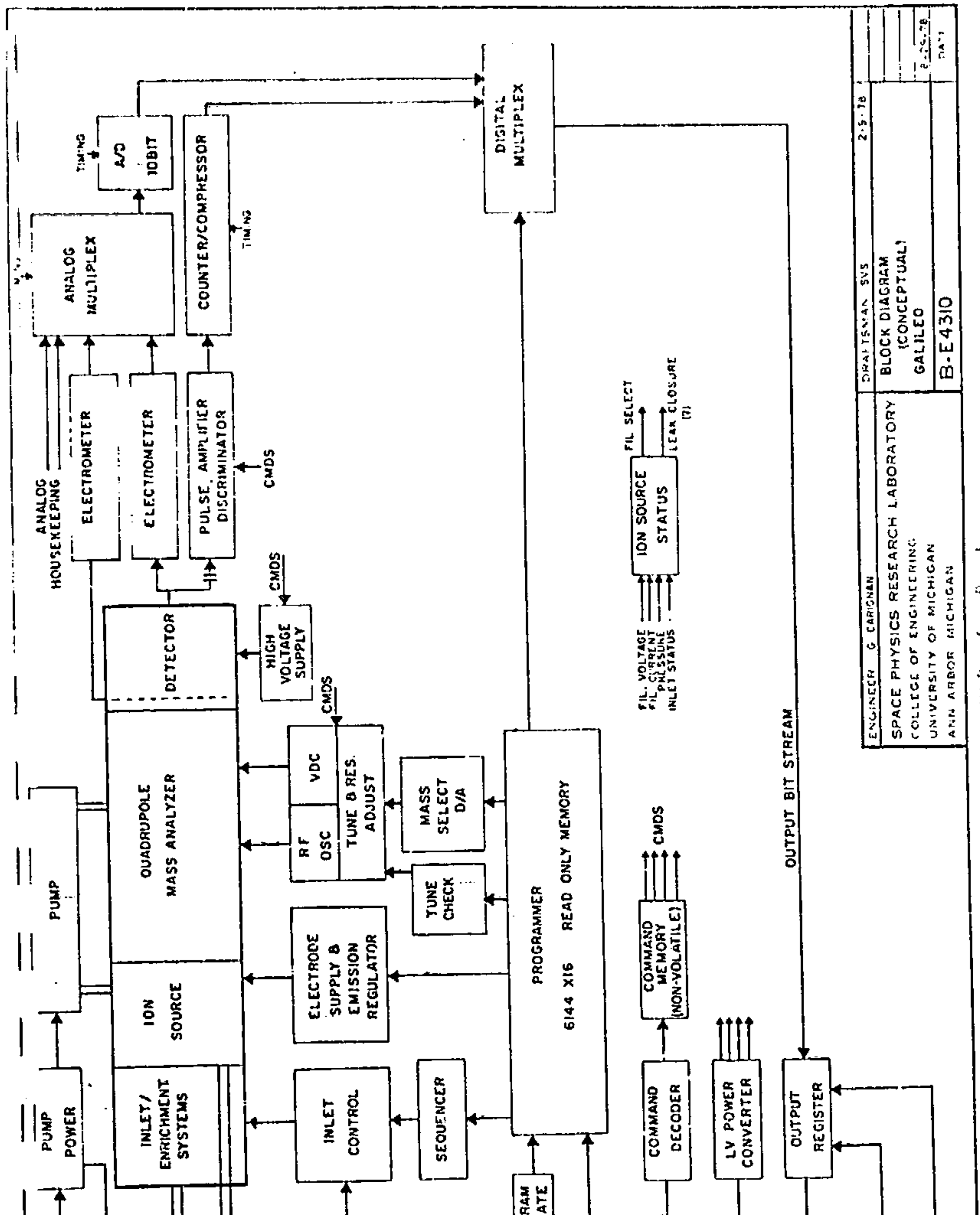
10.1 RF Oscillator Drive Circuitry

10.2 RF Oscillator Sec. and AGC

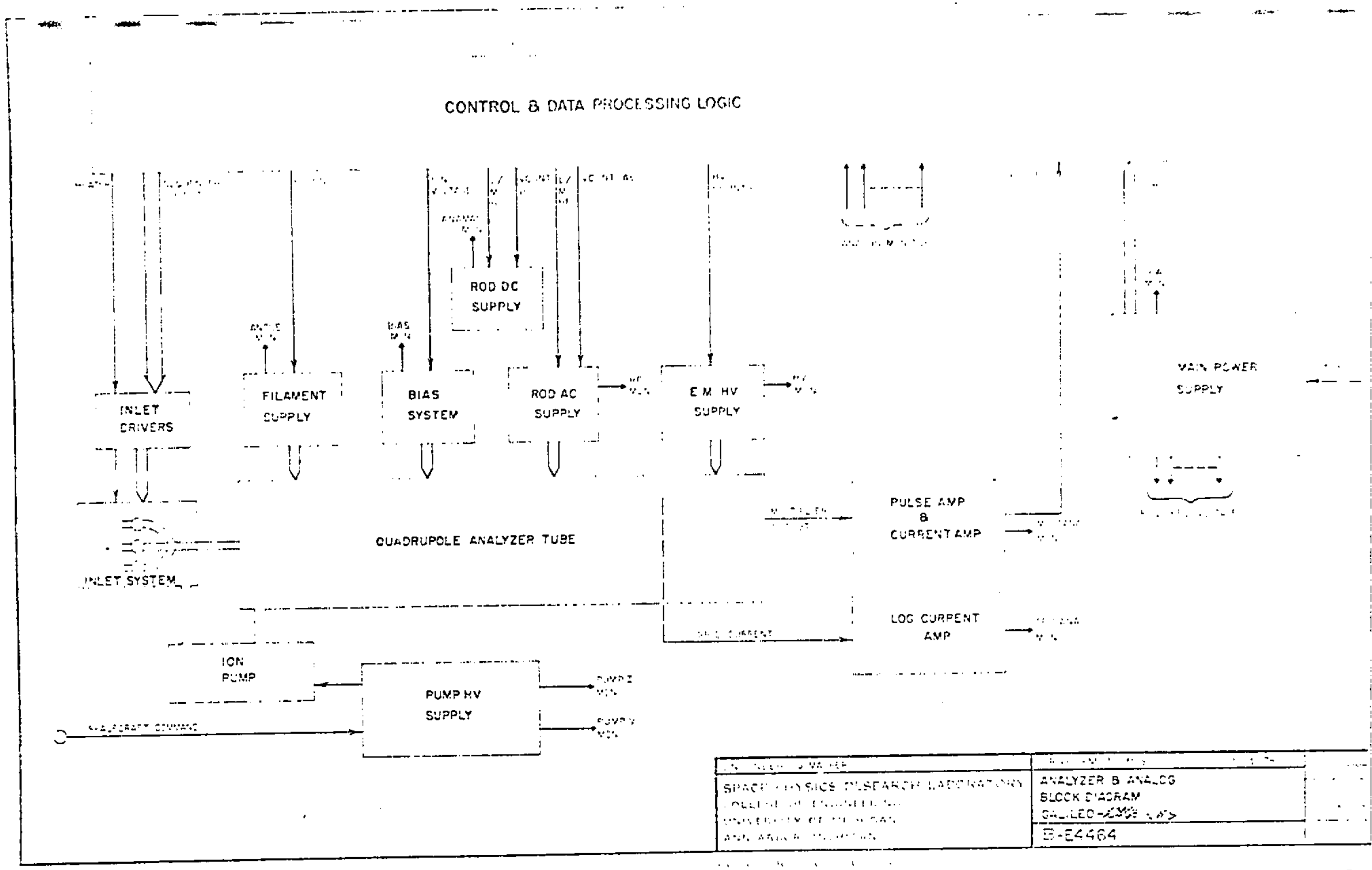
11.1 Pulse Amplifier Hybrid

11.2 Grid Electromtr Amp

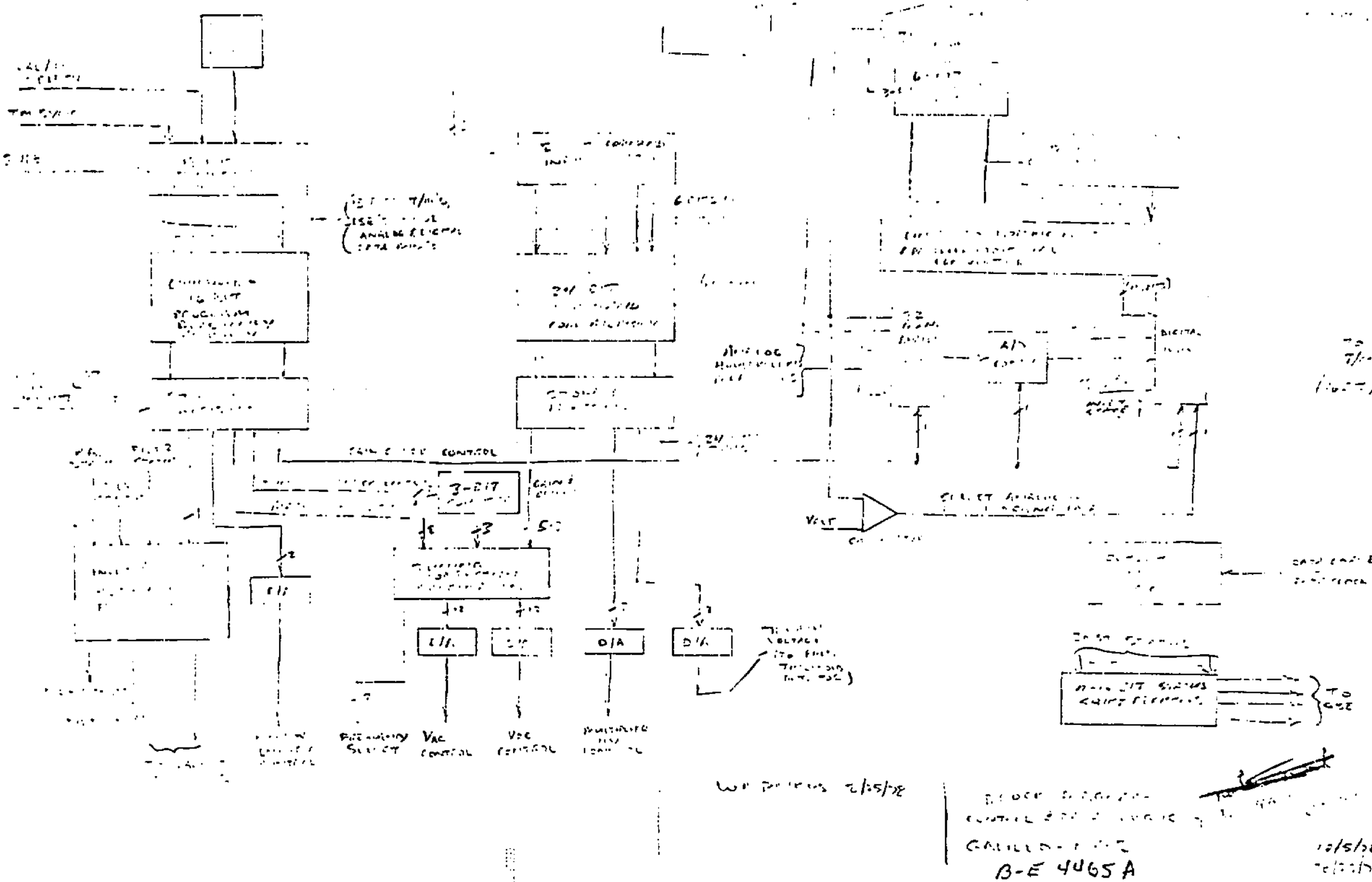
17.1 Floating Point Table


S/C POWER
PUMP CURRENT
ATMOSPHERIC SAMPLES
S/C ORDNANCE ENABLE
S/C EVENT
S/C CLOCK
S/C CMDS
S/C POWER
TO TM
SHIFT
ENABLE
PUMP POWER
PUMP
INLET/ ENRICHMENT SYSTEMS
ION SOURCE
QUADRUPOLE MASS ANALYZER
DETECTOR
INLET CONTROL
SEQUENCER
ELECTRODE SUPPLY & EMISSION REGULATOR
RF OSC
VDC
TUNE & RES. ADJUST
TUNE CHECK
MASS SELECT D/A
HIGH VOLTAGE SUPPLY
CMDS
PROGRAM INITIATE
PROGRAMMER
6144 X16 READ ONLY MEMORY
ANALOG HOUSEKEEPING
ELECTROMETER
ELECTROMETER
PULSE AMPLIFIER DISCRIMINATOR
ANALOG MULTIPLEX
A/D 10BIT
TIMING
COUNTER/COMPRESSOR
DIGITAL MULTIPLEX
COMMAND DECODER
COMMAND MEMORY (NON-VOLATILE)
LV POWER CONVERTER
OUTPUT REGISTER
OUTPUT BIT STREAM
ION SOURCE STATUS
FIL. VOLTAGE
FIL. CURRENT
PRESSURE
INLET STATUS
FIL SELECT
LEAK CLOSURE (2)
ENGINEER G. CARIGNAN
DRAFTSMAN SVS
2-5-78
DATE
SPACE PHYSICS RESEARCH LABORATORY
COLLEGE OF ENGINEERING
UNIVERSITY OF MICHIGAN
ANN ARBOR MICHIGAN
BLOCK DIAGRAM (CONCEPTUAL)
GALILEO
B-E4310

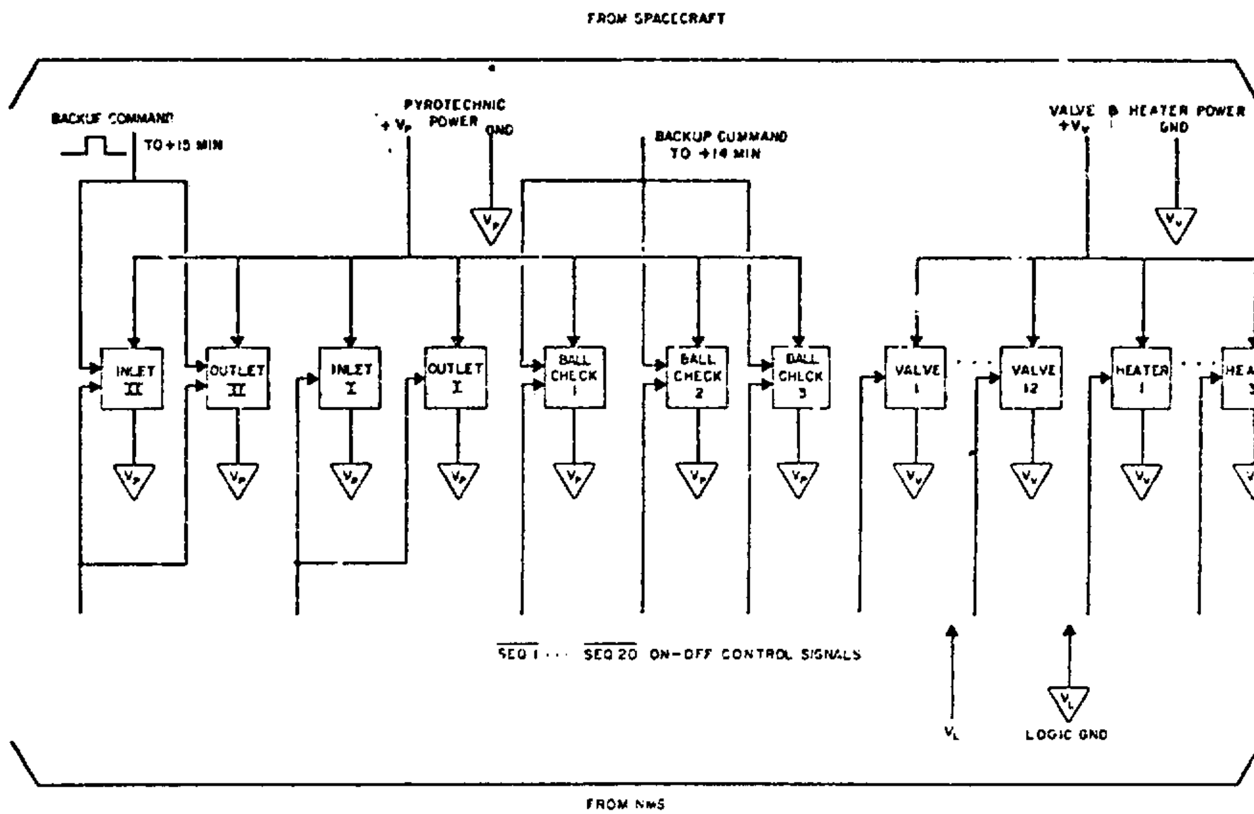
1.1


CONTROL & DATA PROCESSING LOGIC
ROD DC SUPPLY
INLET DRIVERS
FILAMENT SUPPLY
BIAS SYSTEM
ROD AC SUPPLY
E M HV SUPPLY
MAIN POWER SUPPLY
PULSE AMP & CURRENT AMP
QUADRUPOLE ANALYZER TUBE
INLET SYSTEM
LOG CURRENT AMP
ION PUMP
PUMP HV SUPPLY
SPACE PHYSICS RESEARCH LABORATORY
ANALYZER B ANALOG
BLOCK DIAGRAM
B-E4464

1.2


TM SYNC
16 BIT
ANALOG & DIGITAL DATA INPUTS
24 BIT
CONTROL
3-BIT
A/D
D/A
D/A
Vac CONTROL
Vdc CONTROL
FREQUENCY SELECT
DIGITAL
ANALOG
Vref
DATA CARRIES
TO GSE
B-E 4465A
12/5/72

1.3



ENGINEER J CALDWELL

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UNIVERSITY OF MICHIGAN
ANN ARBOR, MICHIGAN

DRAFTSMAN SVS 8-25-78

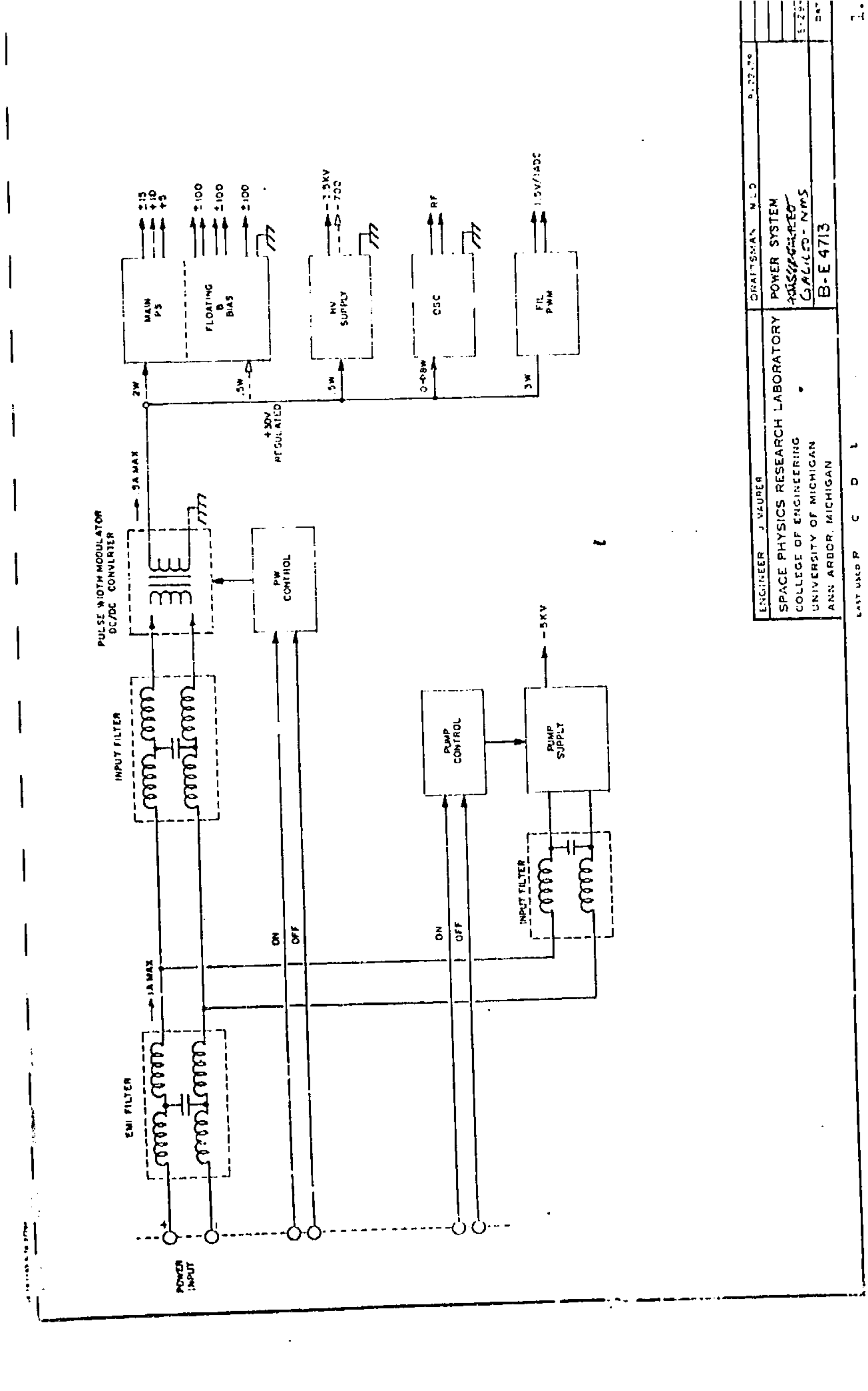
INLET SYSTEM DRIVE
CIRCUITS BLOCK DIAGRAM
GALILEO - NMS

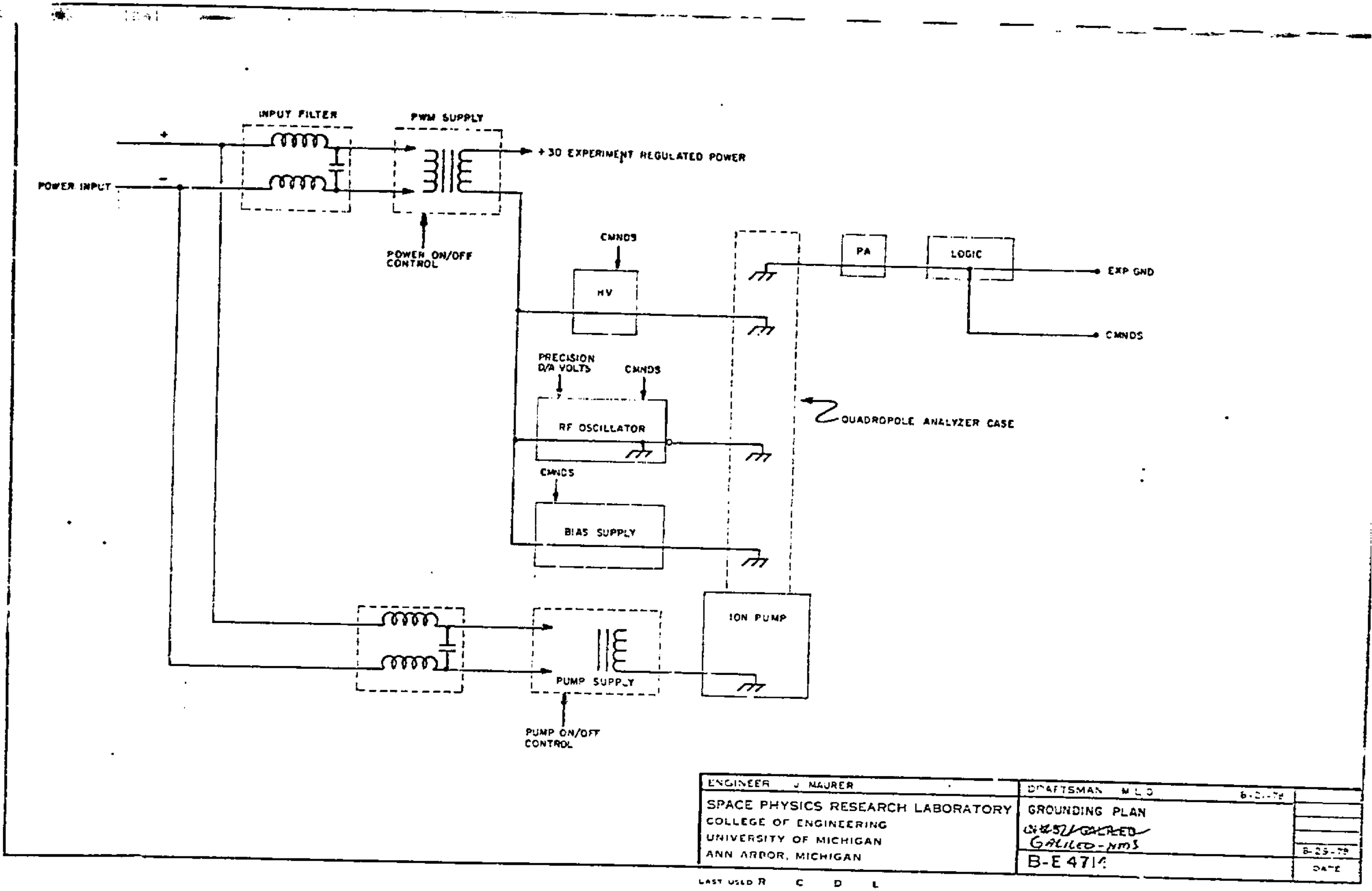
B-E4500

DATE

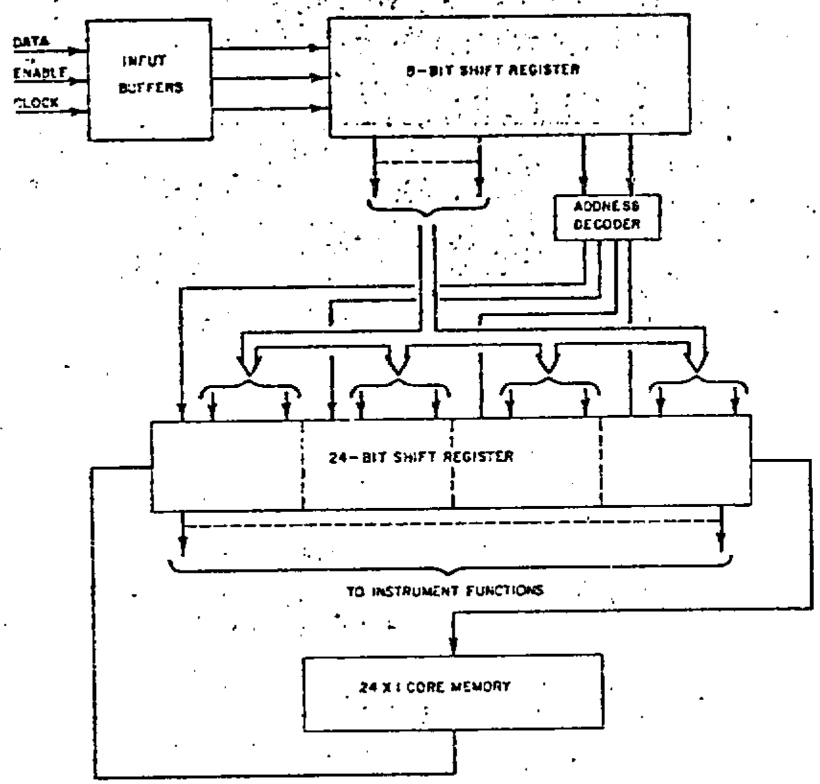
LAST USED R C D L

1.4


POWER INPUT
EMI FILTER
INPUT FILTER
PULSE WIDTH MODULATOR DC/DC CONVERTER
PW CONTROL
MAIN PS
FLOATING & BIAS
HV SUPPLY
OSC
FIL PWM
PUMP CONTROL
PUMP SUPPLY
ON
OFF
+30V REGULATED
RF
-5KV
ENGINEER J VAURER
DRAFTSMAN
SPACE PHYSICS RESEARCH LABORATORY
COLLEGE OF ENGINEERING
UNIVERSITY OF MICHIGAN
ANN ARBOR, MICHIGAN
POWER SYSTEM
GALILEO - NMS
B-E 4713


INPUT FILTER
PWM SUPPLY
+
-
POWER INPUT
+30 EXPERIMENT REGULATED POWER
POWER ON/OFF CONTROL
CMNDS
HV
PRECISION D/A VOLTS
CMNDS
RF OSCILLATOR
CMNDS
BIAS SUPPLY
PA
LOGIC
EXP GND
CMNDS
QUADROPOLE ANALYZER CASE
ION PUMP
PUMP SUPPLY
PUMP ON/OFF CONTROL
ENGINEER J. MAURER
SPACE PHYSICS RESEARCH LABORATORY
COLLEGE OF ENGINEERING
UNIVERSITY OF MICHIGAN
ANN ARBOR, MICHIGAN
DRAFTSMAN
GROUNDING PLAN
GALILEO-NMS
B-E 4714
DATE
LAST USED R C D L

1.6



BIT / WD	8	7	6	5	4	3	2	1
0	0	0	6	5	4	3	2	1
1	0	1	12	11	10	9	8	7
2	1	0	18	17	16	15	14	13
3	1	1	24	23	22	21	20	19

ADDRESS BITS
(FOUR QUANTATIVE WORDS TO COMPLETELY CONFIGURE TUNE MEMORY)

1. CORE FULLY REWRITTEN AFTER EACH RECEPTION
2. CORE DUMPED INTO REGISTER & REWRITTEN AT EACH POWER TURN-ON

ENGINEER W H PINKUS

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UNIVERSITY OF MICHIGAN
ANN ARBOR, MICHIGAN

DRAFTSMAN MSS 10-20-78

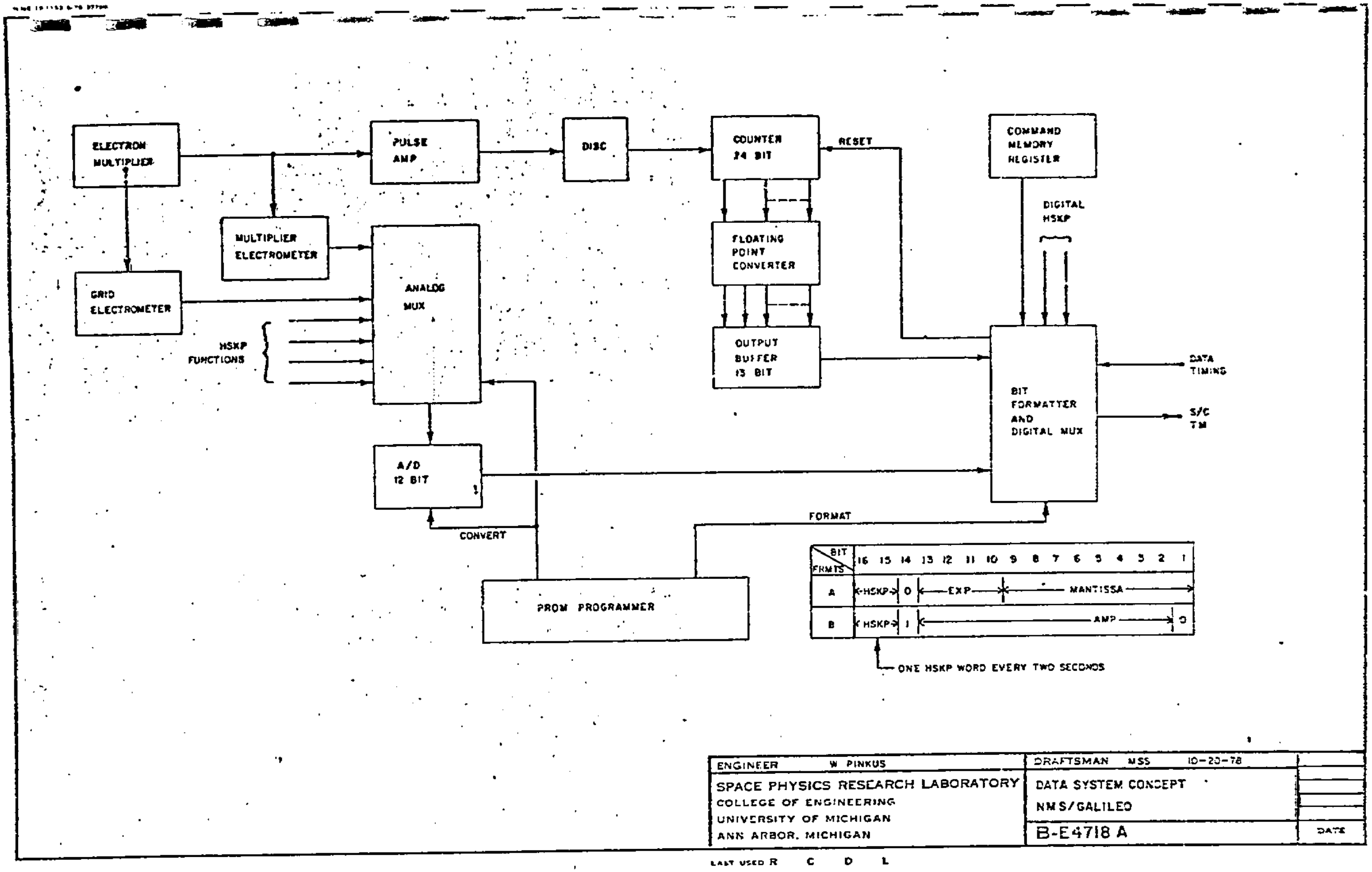
COMMAND SYSTEM CONCEPT
NMS/GALILEO

B-E4717A

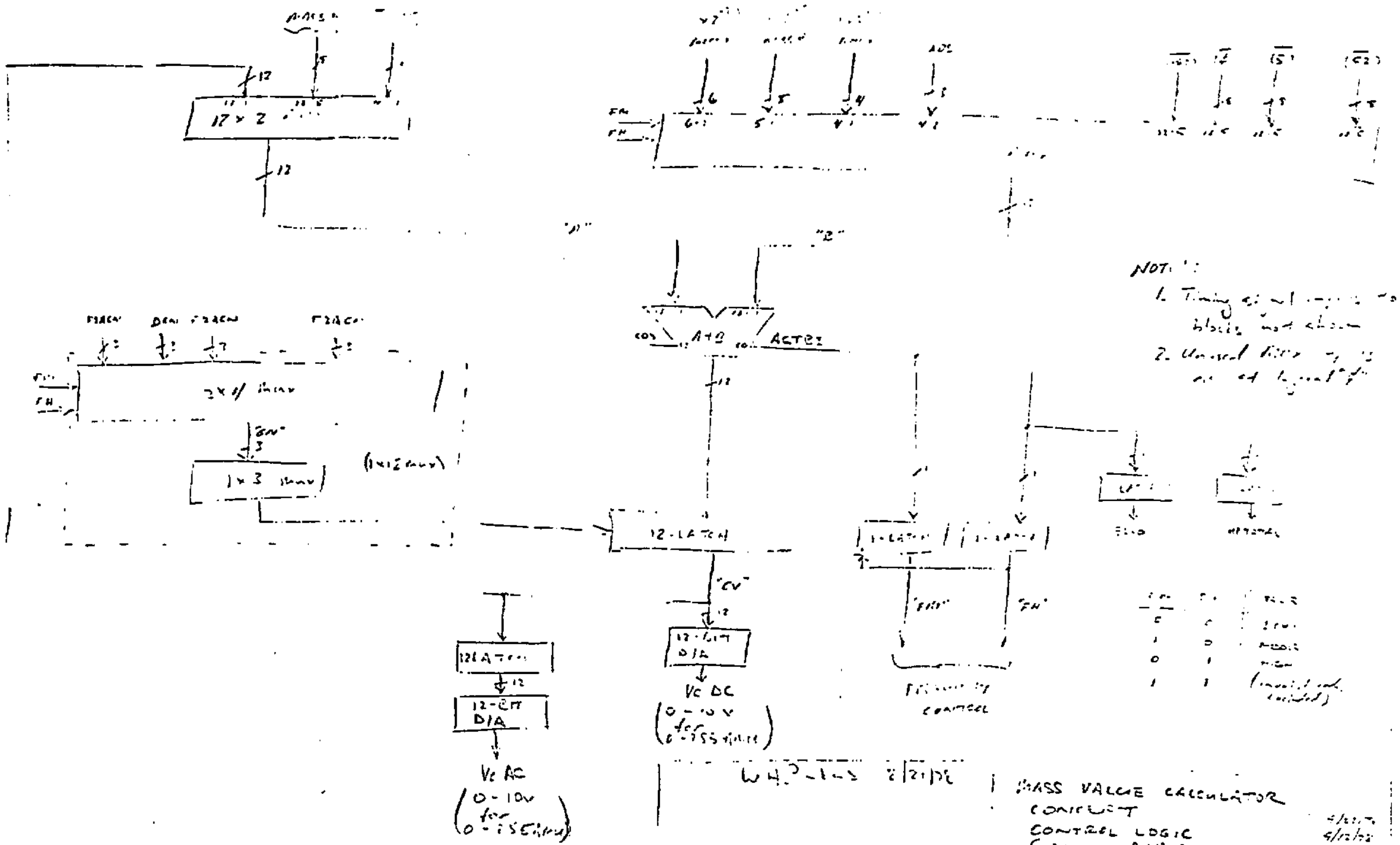
DATE

LAST USED R °C D L

1.7


ELECTRON MULTIPLIER
PULSE AMP
DISC
COUNTER 24 BIT
RESET
COMMAND MEMORY REGISTER
MULTIPLIER ELECTROMETER
GRID ELECTROMETER
ANALOG MUX
HSKP FUNCTIONS
FLOATING POINT CONVERTER
OUTPUT BUFFER 13 BIT
DIGITAL HSKP
BIT FORMATTER AND DIGITAL MUX
DATA TIMING
S/C TM
A/D 12 BIT
CONVERT
FORMAT
PROM PROGRAMMER
BIT
FRMTS
16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1
A
HSKP
0
EXP
MANTISSA
B
HSKP
1
AMP
0
ONE HSKP WORD EVERY TWO SECONDS
ENGINEER W PINKUS
DRAFTSMAN MSS 10-20-78
SPACE PHYSICS RESEARCH LABORATORY
COLLEGE OF ENGINEERING
UNIVERSITY OF MICHIGAN
ANN ARBOR, MICHIGAN
DATA SYSTEM CONCEPT
NMS/GALILEO
B-E4718 A
DATE
LAST USED R C D L

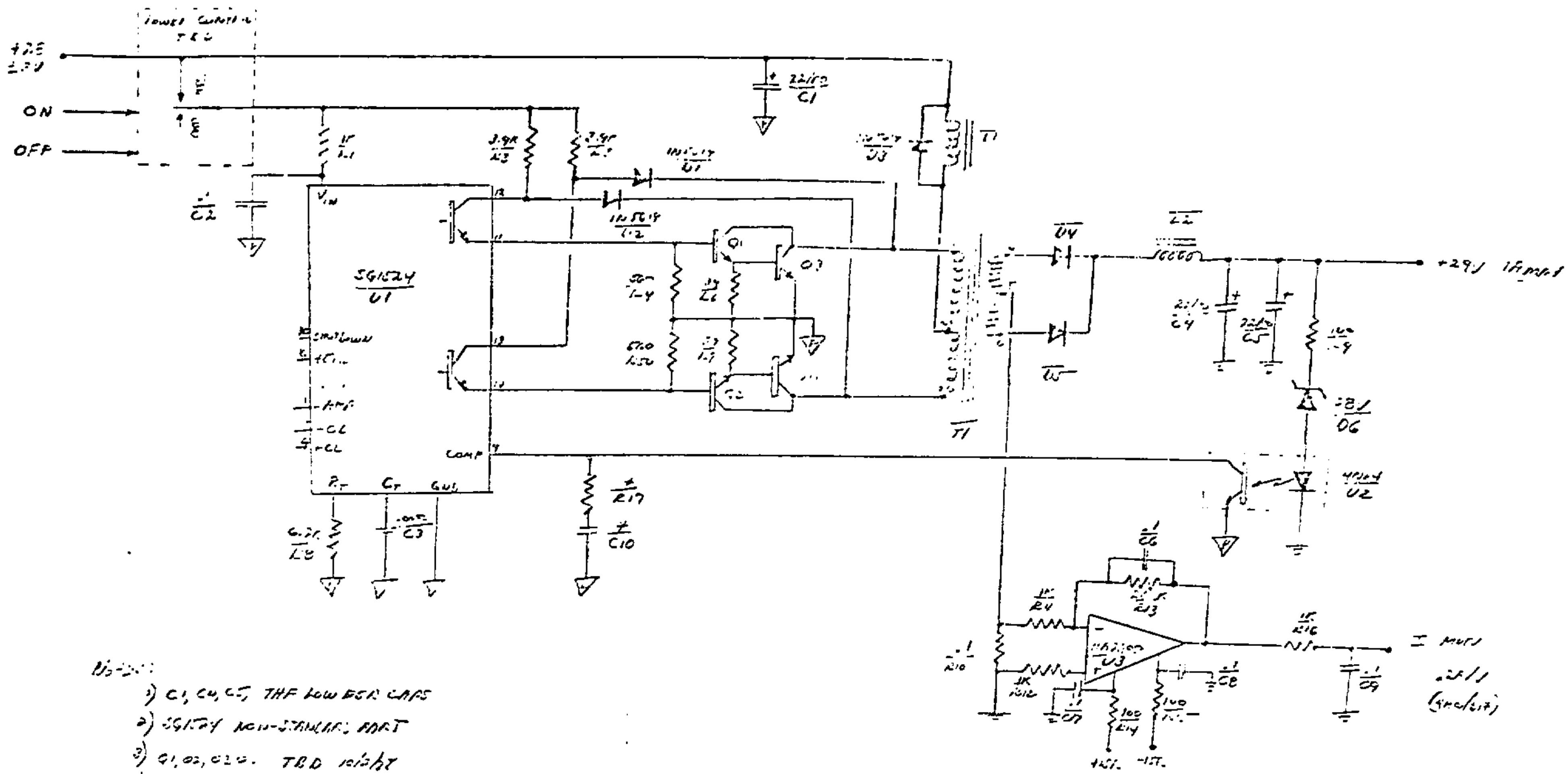
1.8



WHP

MASS VALUE CALCULATOR
CONCEPT
CONTROL LOGIC
GALILEO NIMS
E4829

1.9



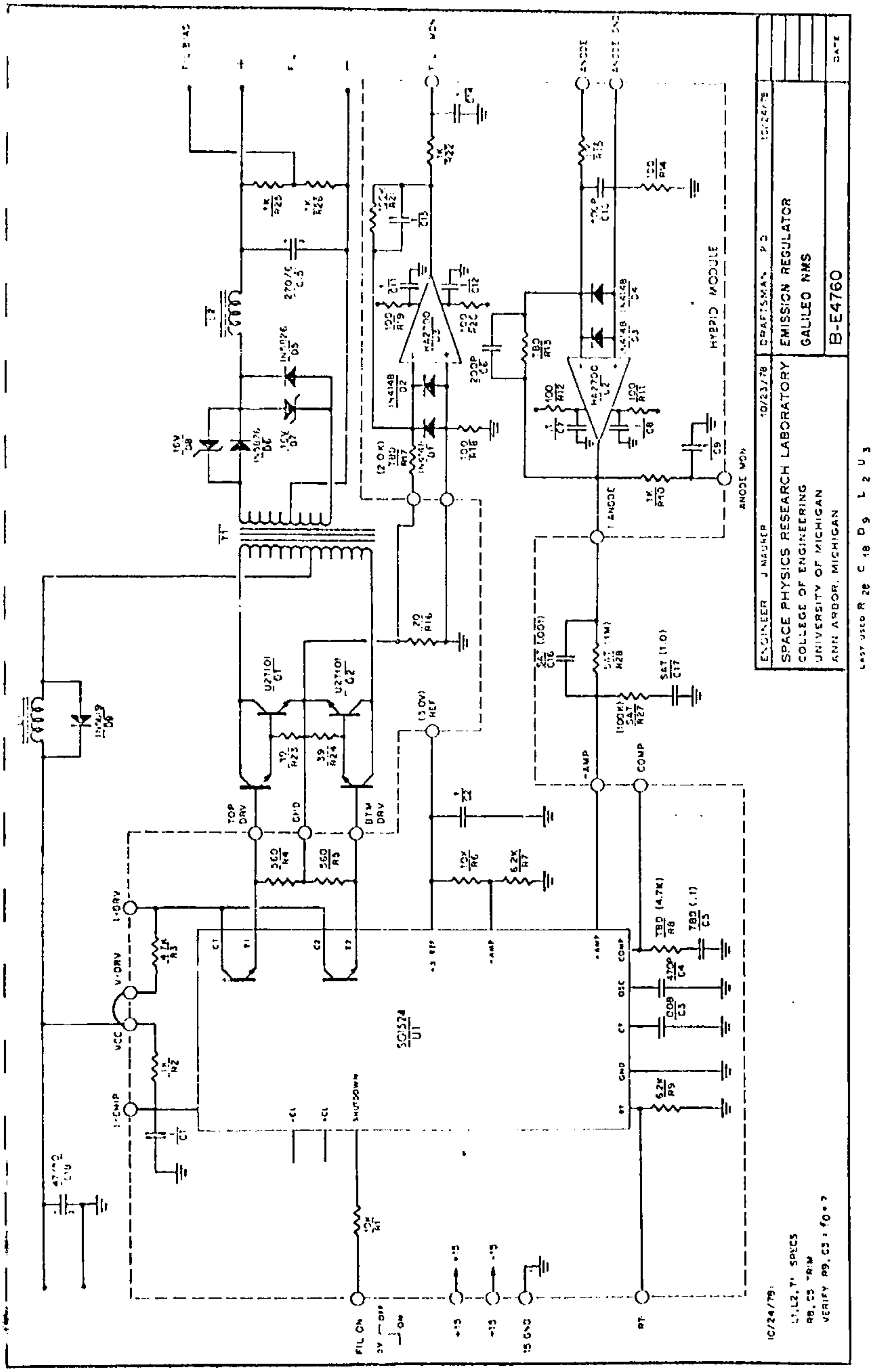
Notes:

1) C1, C4, C5, THE LOW ESR CAPS
2) SG1524 NON-STANDARD PART
3) Q1, Q2, Q3. TBD 10/3/77
4) D4, D5 TBD 10/3/77
5) D6 SELECTED FOR 28.5 ±.5V
6) SPECS. FOR T1, L1, L2, TBD 10/3/77
7) * SELECT AT TEST OR TBD!

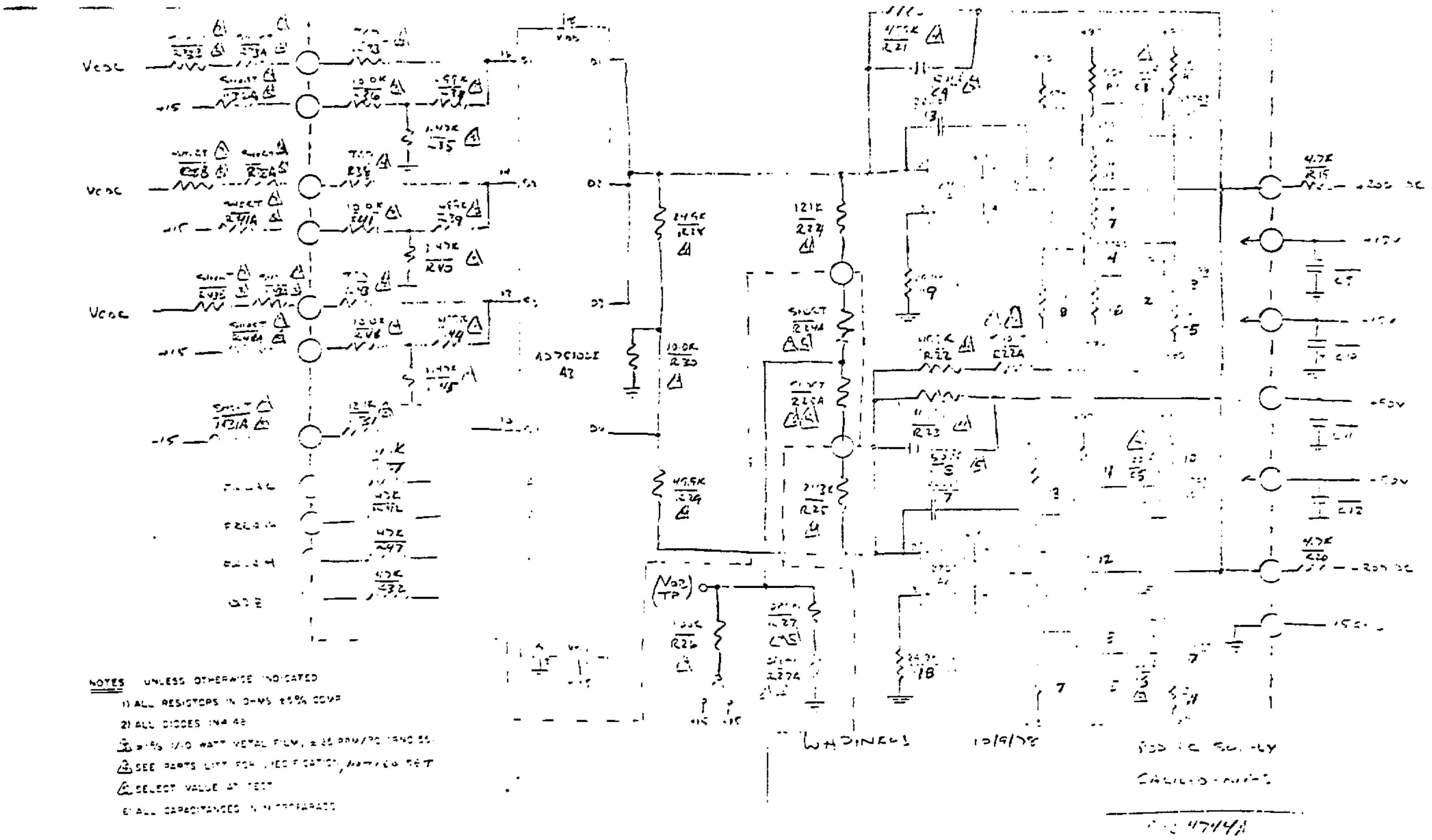
+29 REGULATOR MAURER 10/3/77
GALILEO NIMS E4005

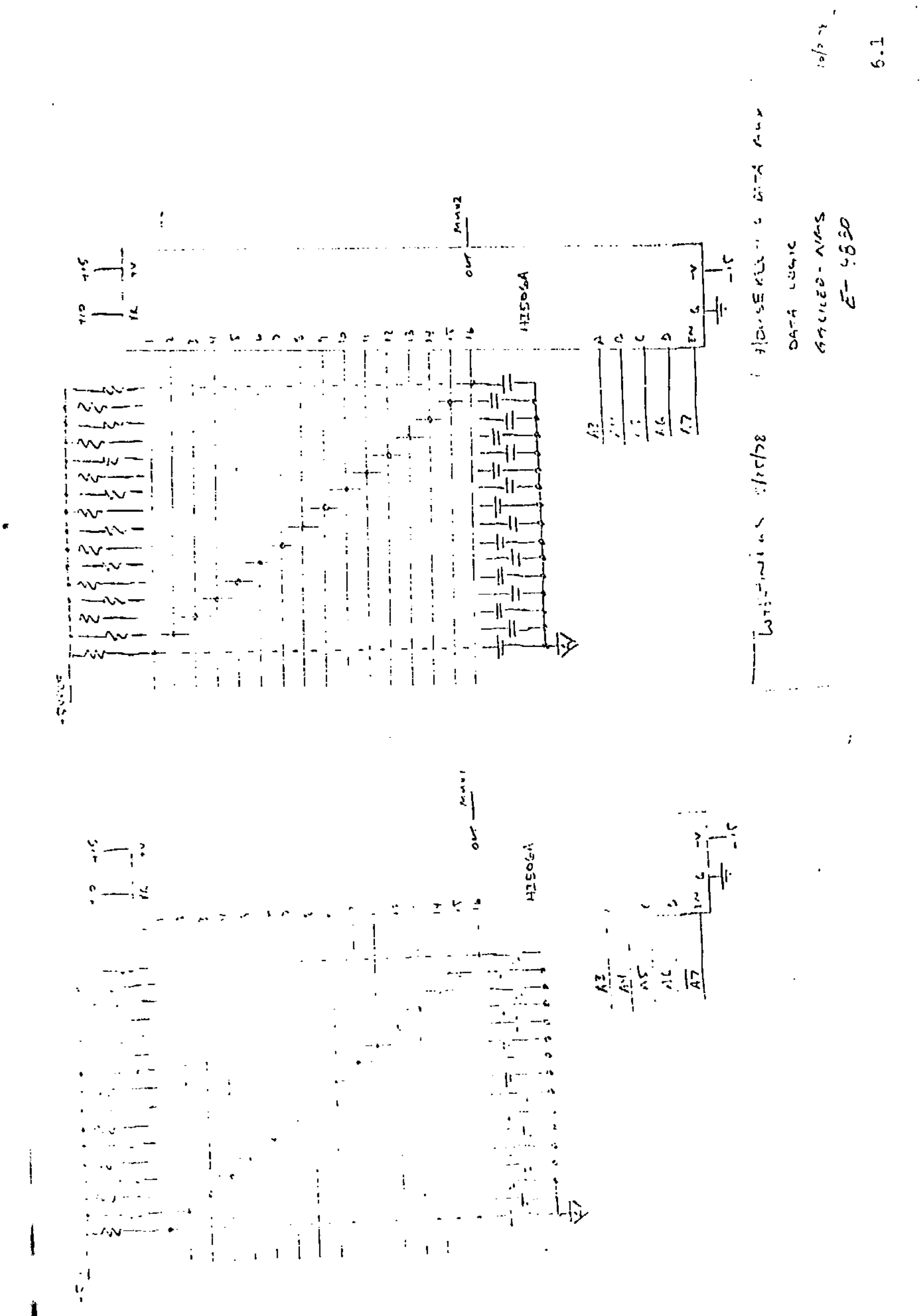
R17 C10 NC

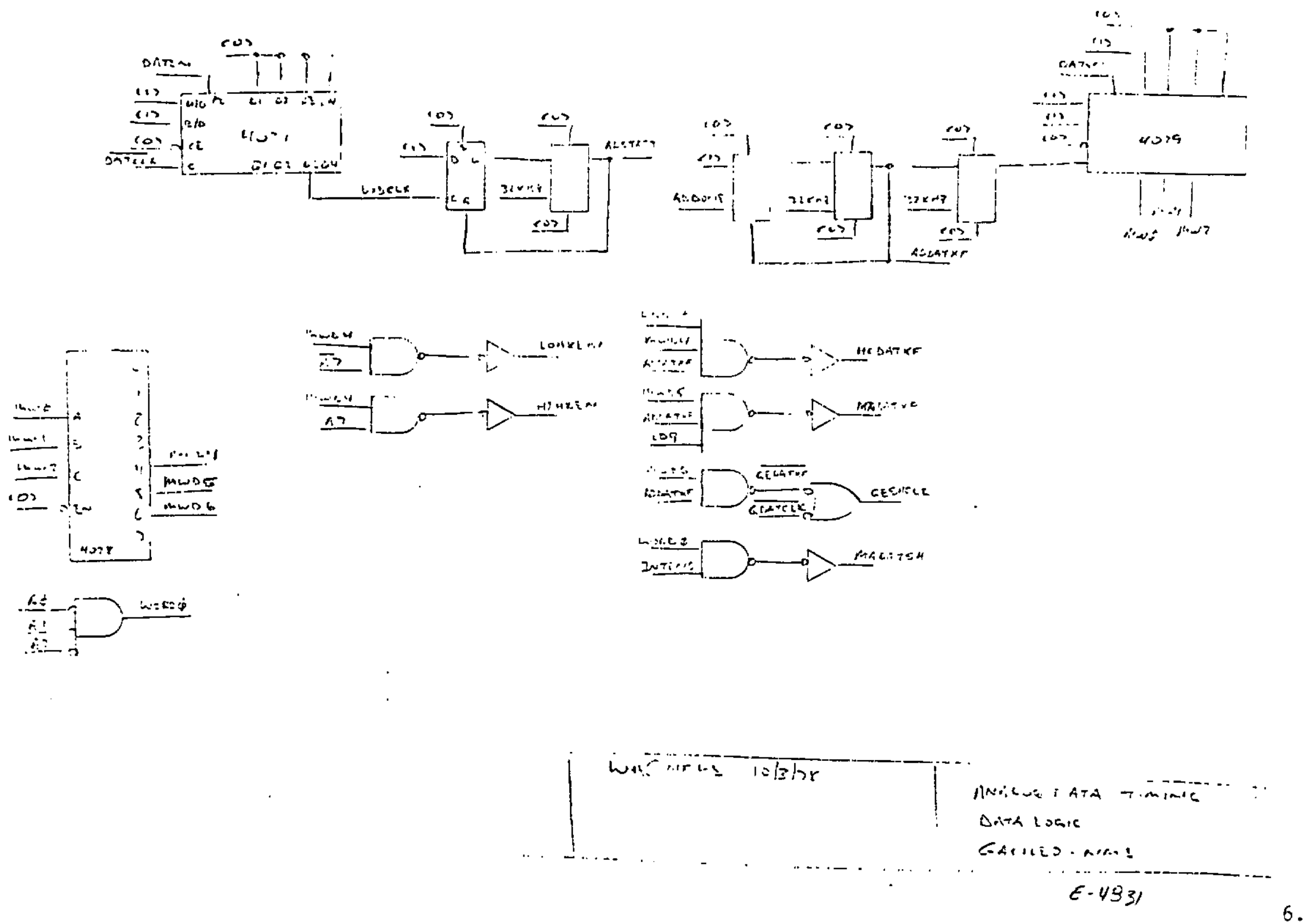
3.2

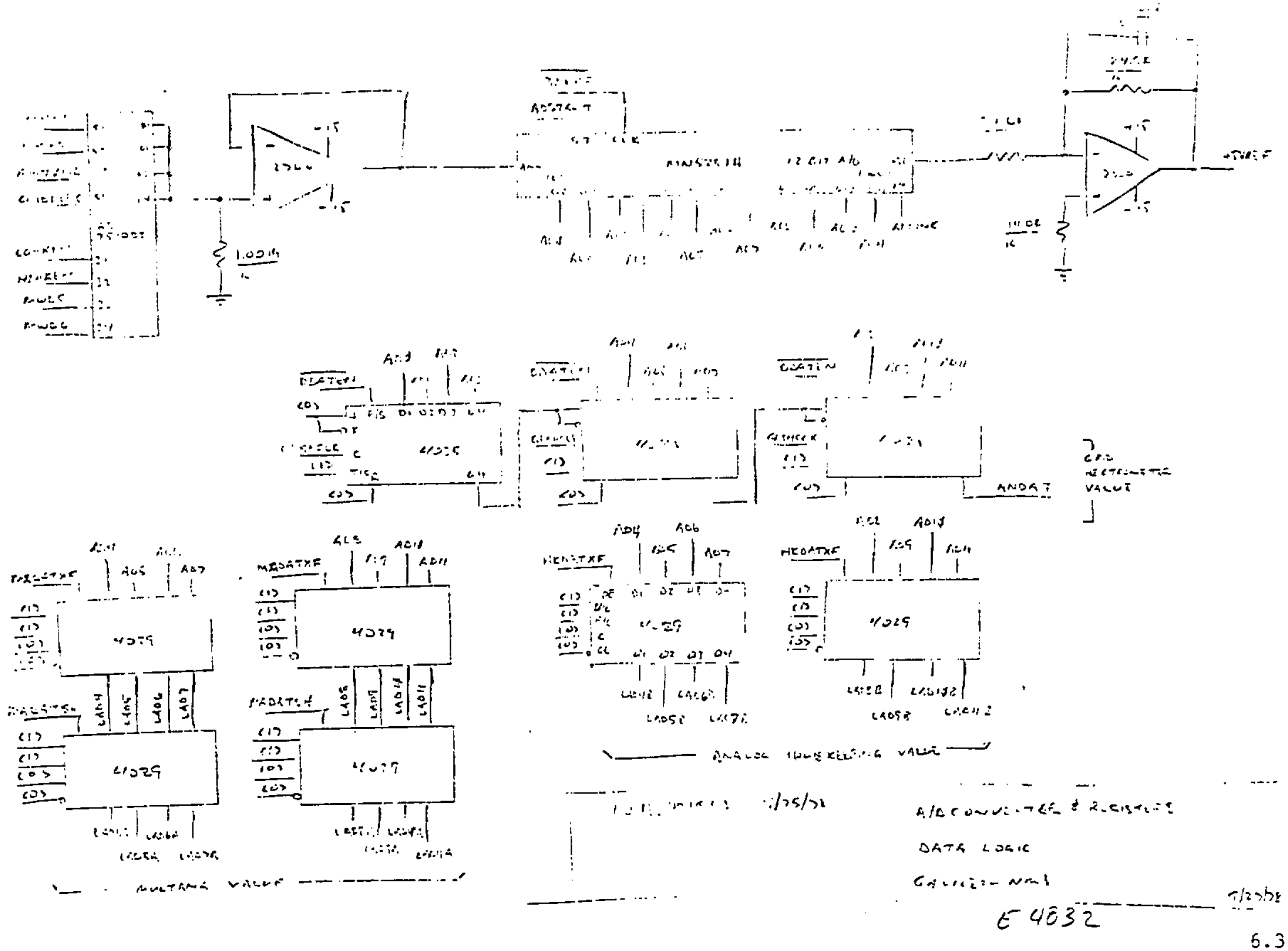


EMISSION REGULATOR
GALILEO NMS
B-E4760
SPACE PHYSICS RESEARCH LABORATORY
COLLEGE OF ENGINEERING
UNIVERSITY OF MICHIGAN
ANN ARBOR, MICHIGAN
HYBRID MODULE

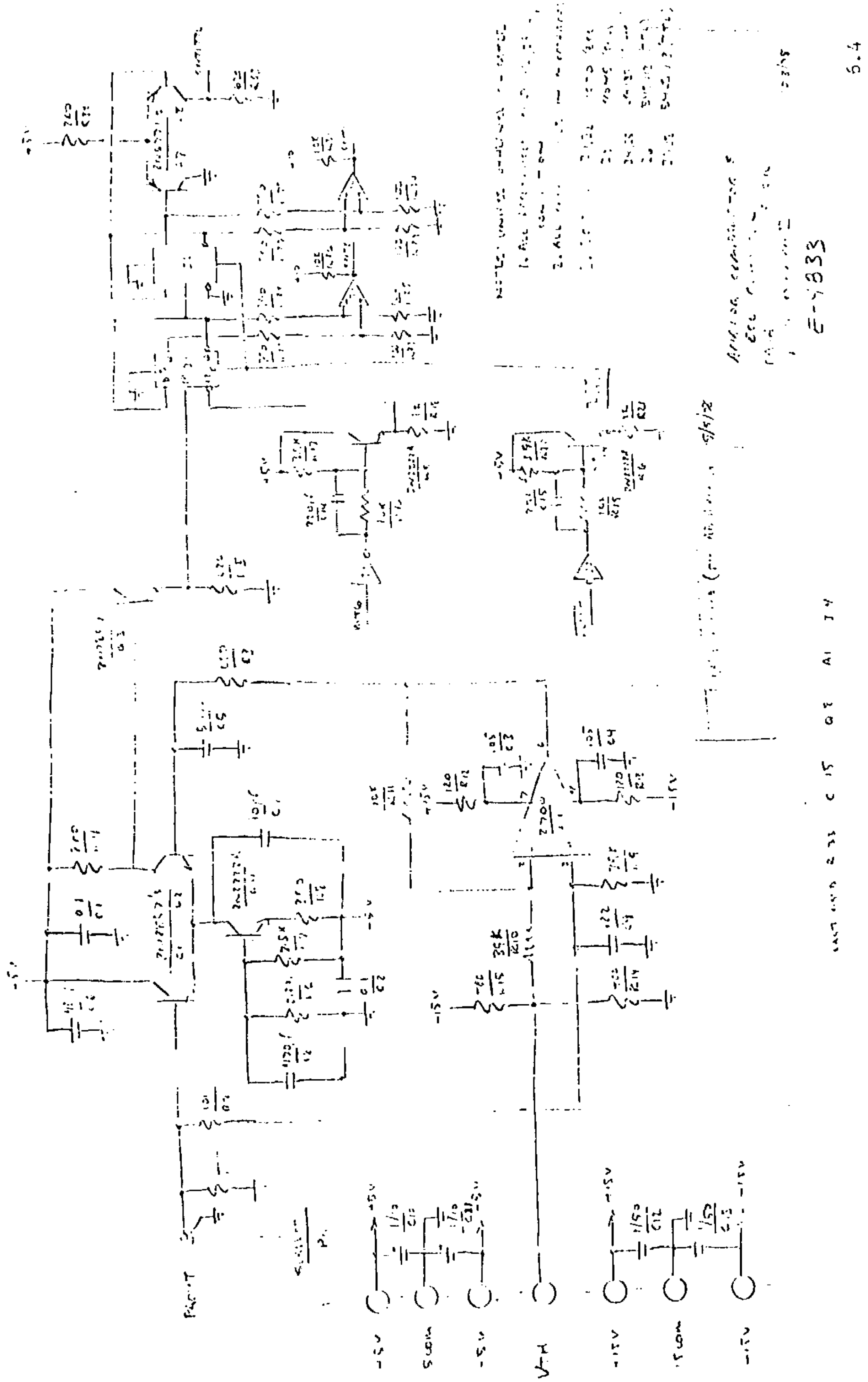

Vcoc
Vcoc
Vcoc
R15
R20
R21
R22
R23
R26
R29
R24
R25
R30
R31
R35
R36
R39
R40
R41
R47
R49
ADDCIDDE 43
NOTES UNLESS OTHERWISE INDICATED
1) ALL RESISTORS IN OHMS ±5% COMP
2) ALL DIODES 1N4148
SEE PARTS LIST FOR SPECIFICATION
SELECT VALUE AT TEST
6) ALL CAPACITANCES IN MICROFARADS
5.1

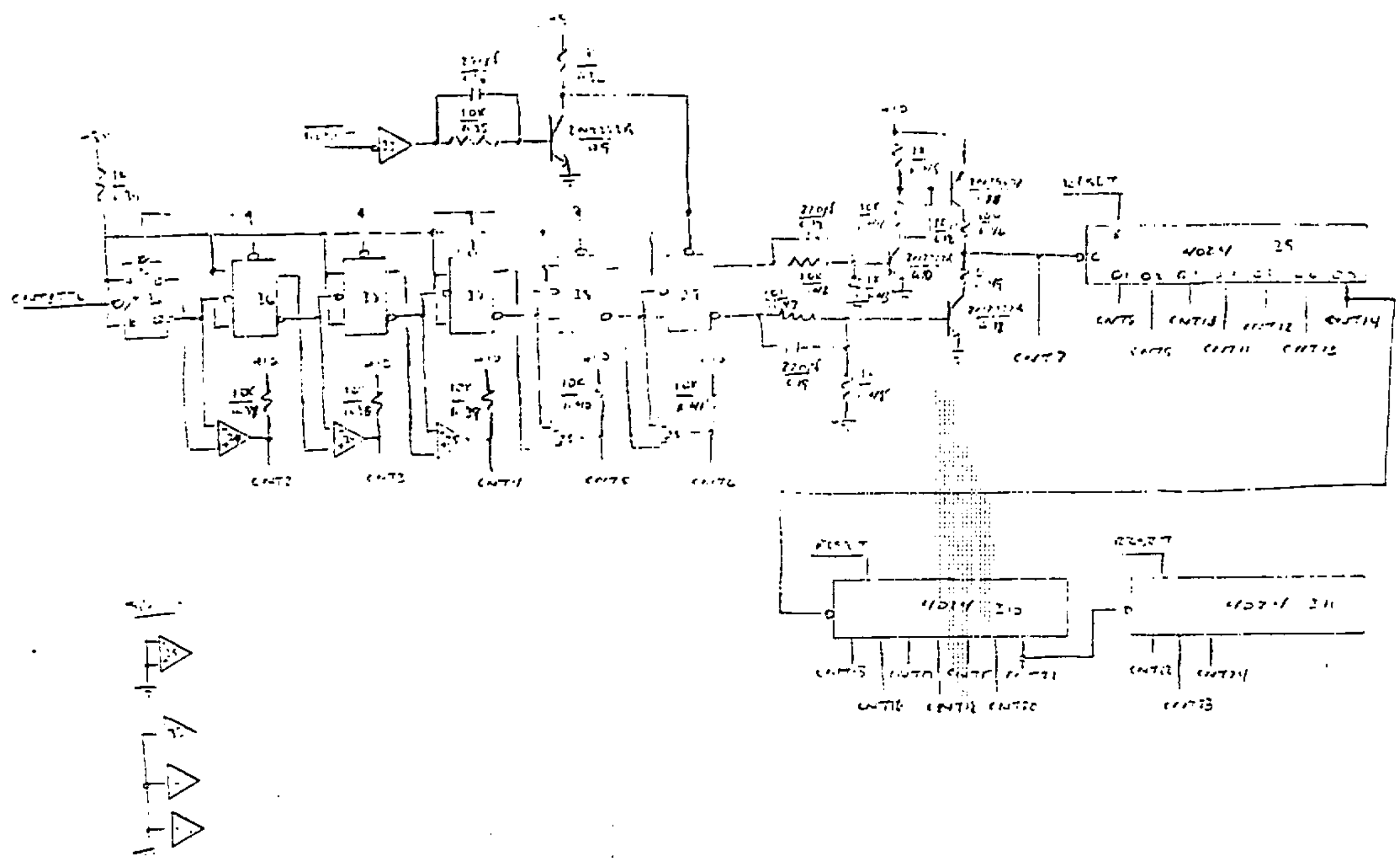

HI506A


ANALOG DATA TIMING
DATA LOGIC
E-4331
6.2



4029
DATA LOGIC
E 4032
6.3



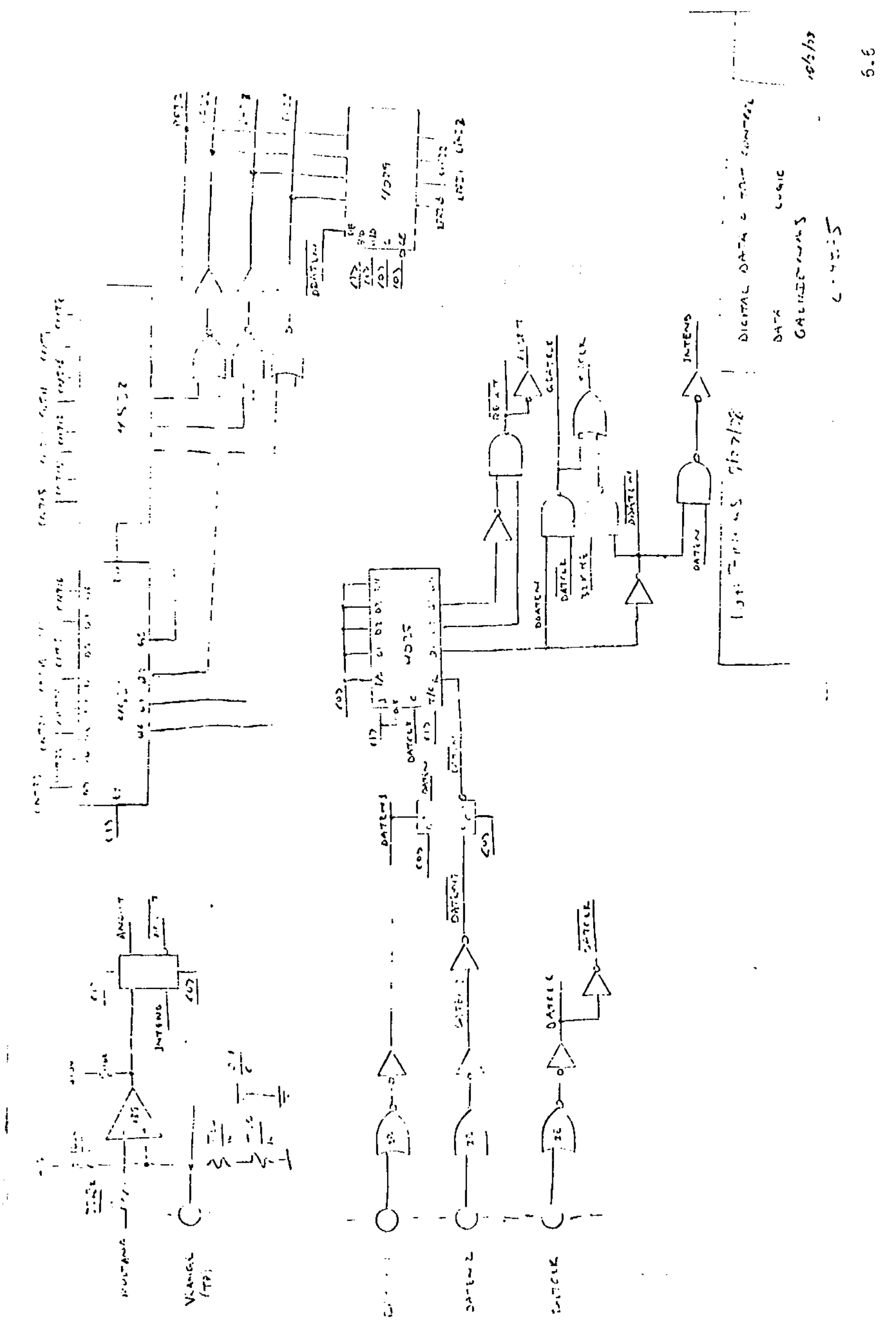


9/5/78

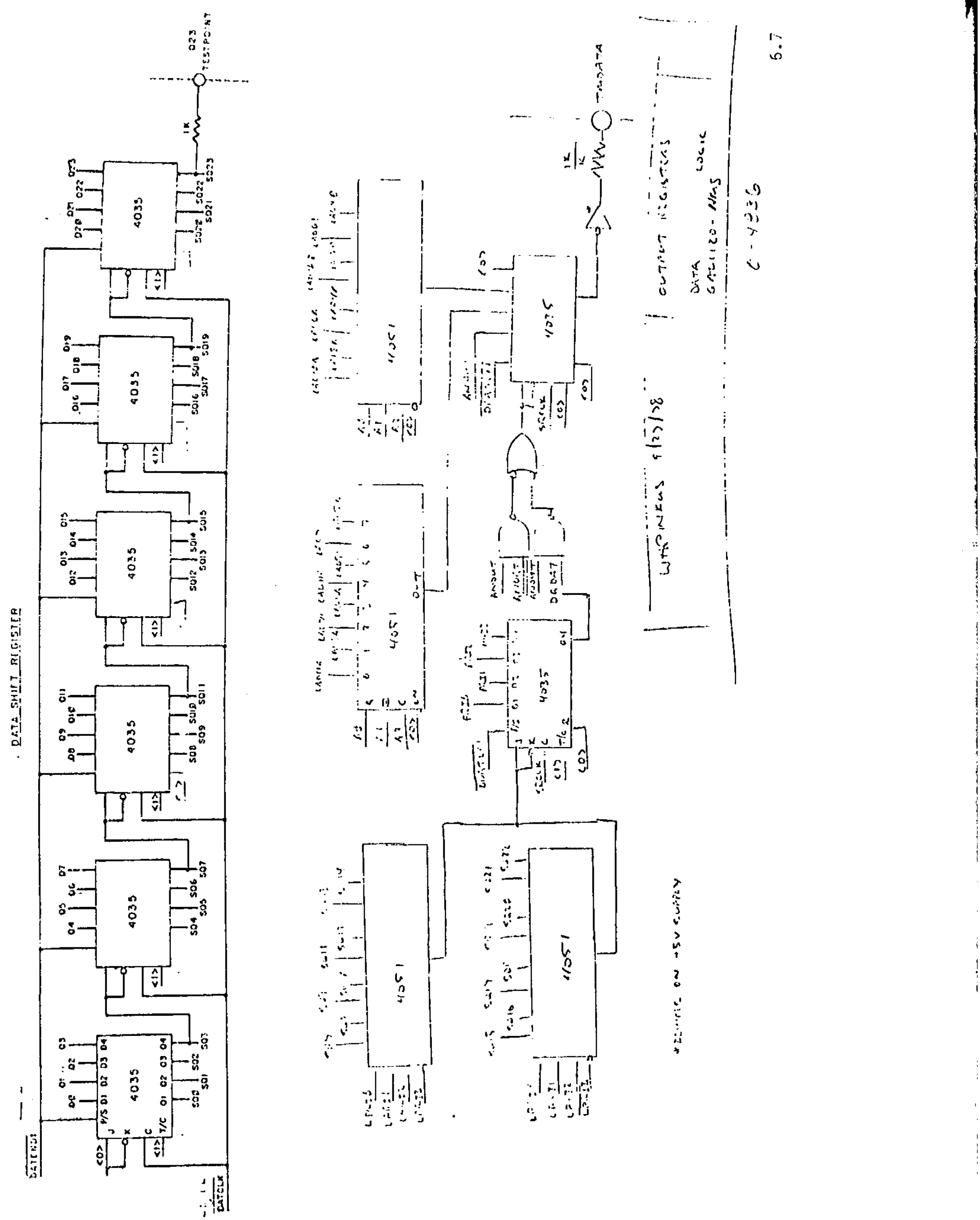
TTL & CMOS COUNTERS

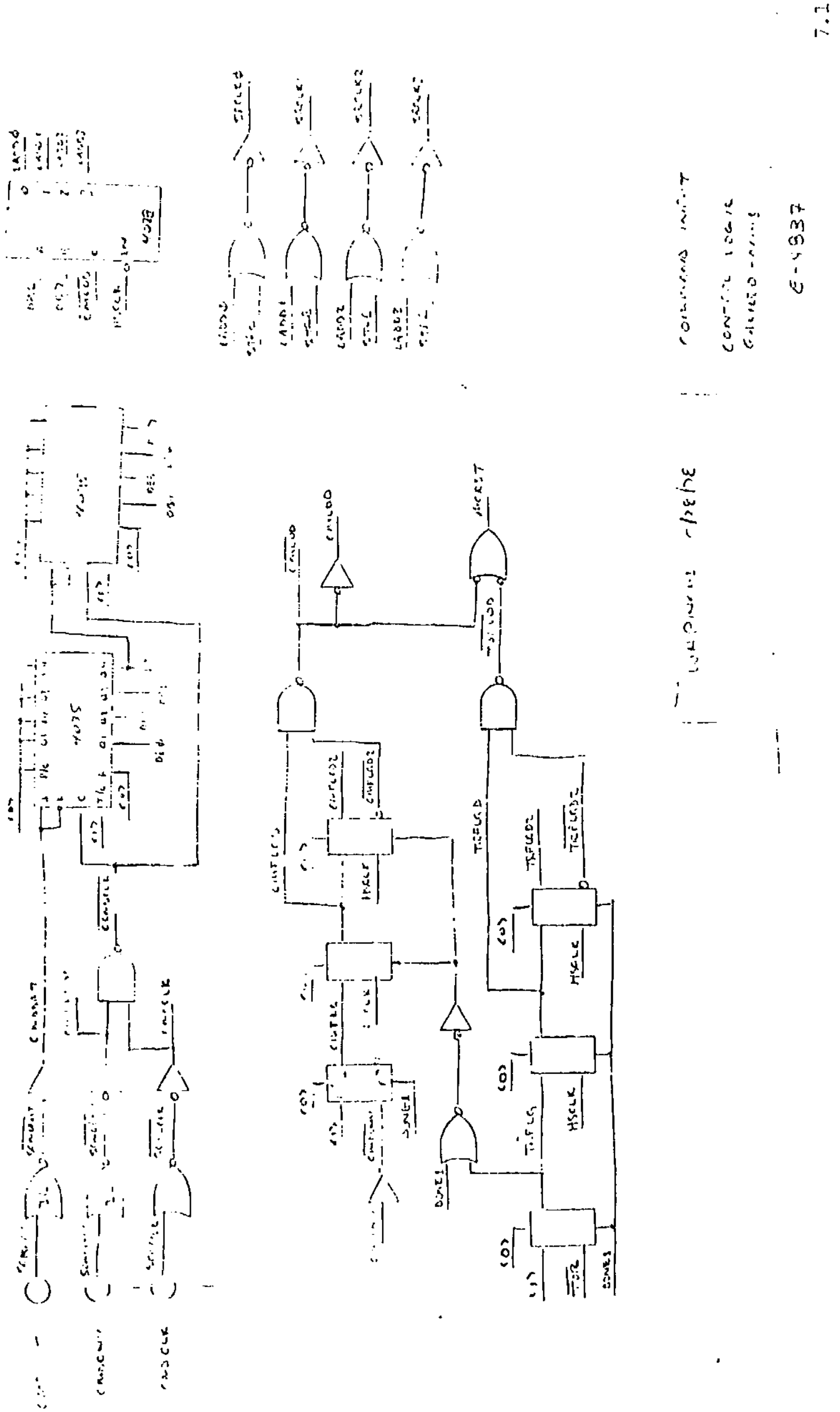
E-4834

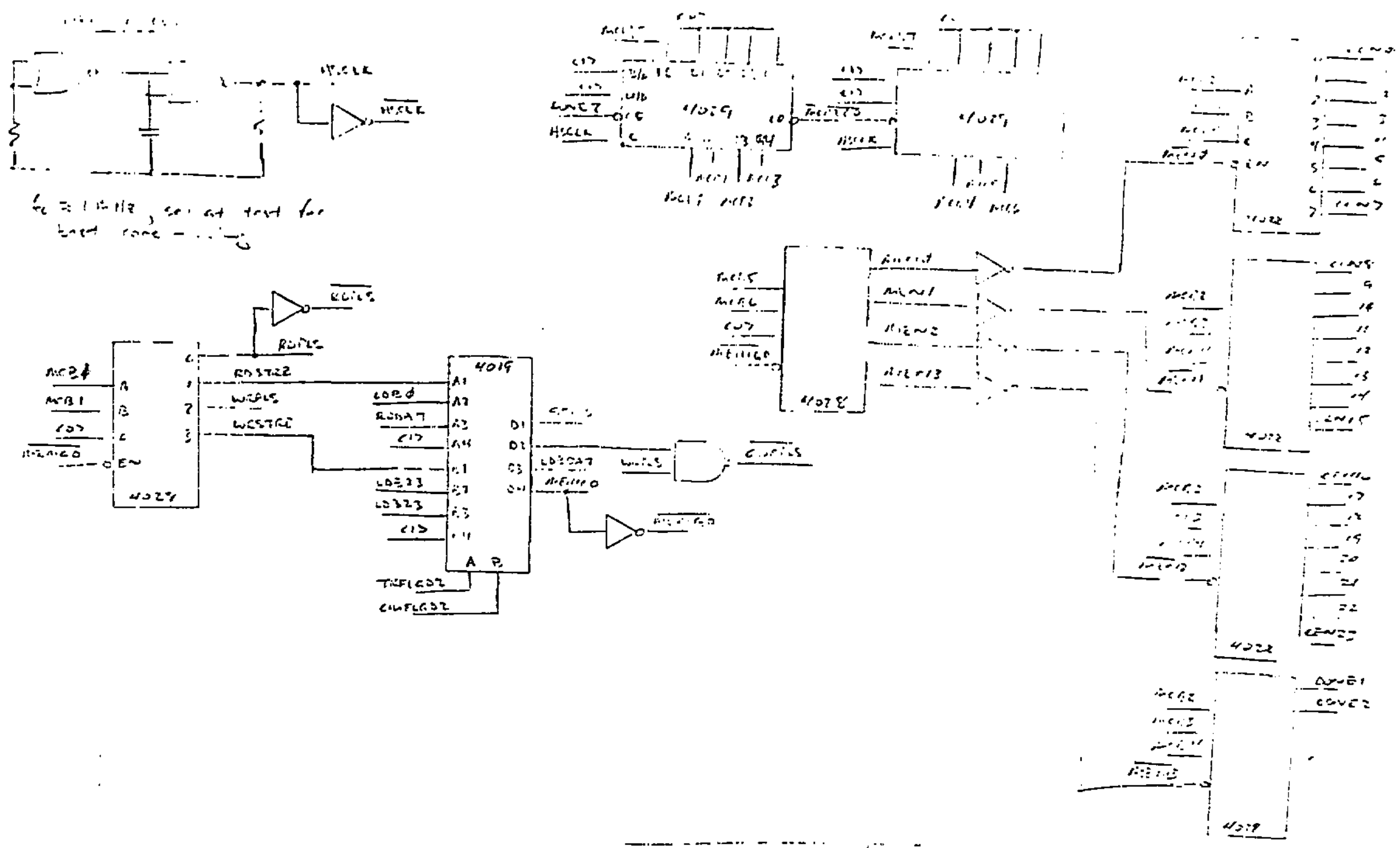
6.5



INTENS
DATEN
DATCLK


DATA SHIFT REGISTER
4035
D23 TESTPOINT
1K
4051
4075
TXDATA
6.7


E-4937
7.1

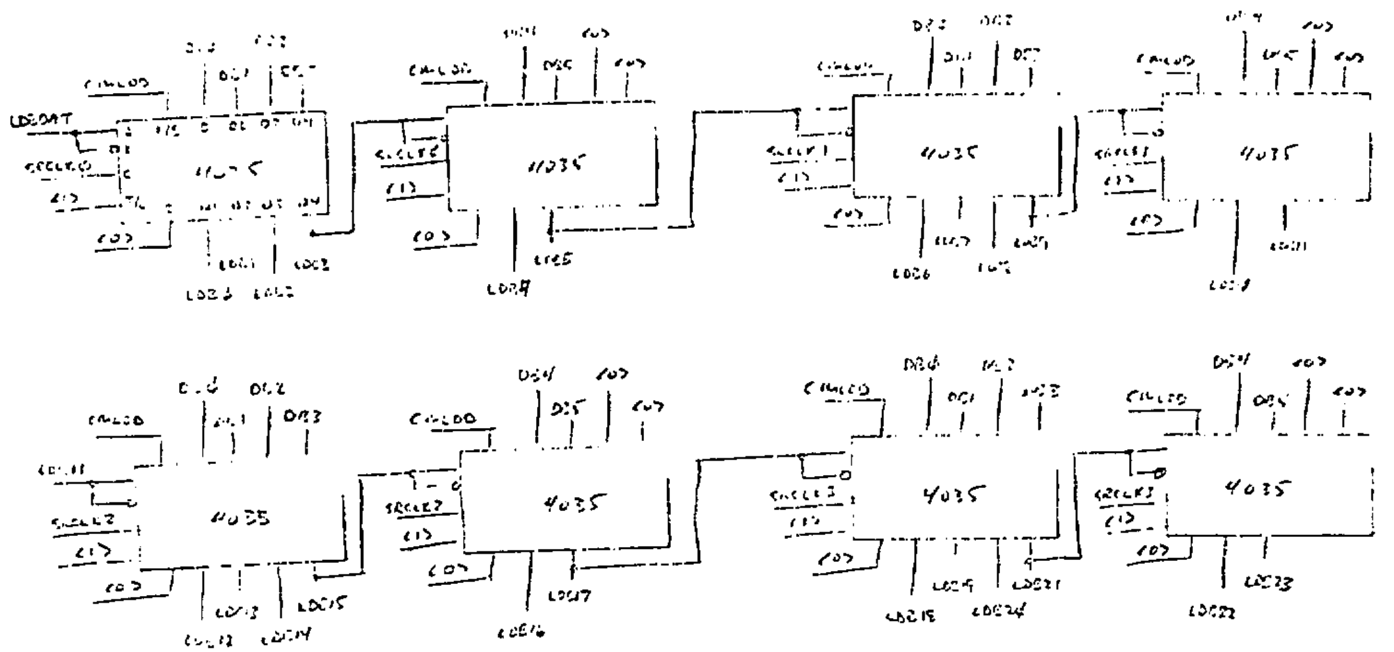


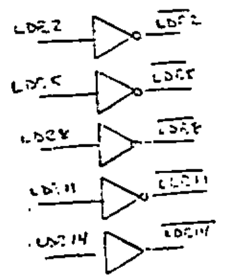
COMMAND MEMORY CONTROL

CONTROL LOGIC

E-4233

7.2





0-2 AC OFFSET
3-5 FH AC GAIN
6-8 FBI AC GAIN
9-11 F2 AC GAIN
12-14 DC GAIN
15-17 SPARE
18-20 MULTIPLIER HV
21-22 PULSE AMP DISCRIM. REF.
23 SPARE

WHCRELLS 9/28/78

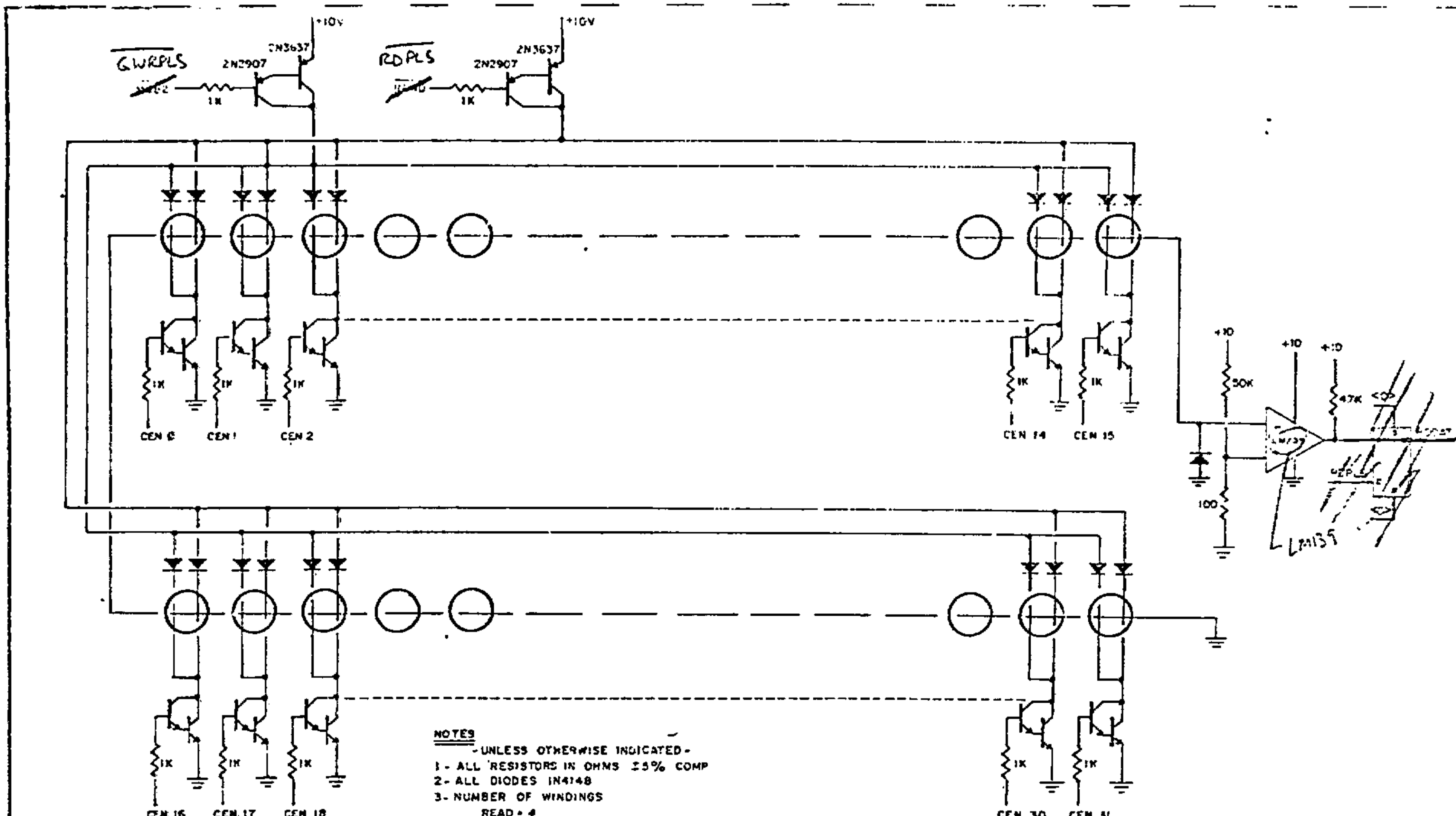
COMMAND BUFFER

CONTROL LOGIC
GALILEO - NMS

10/4/78

E-4839

7.3

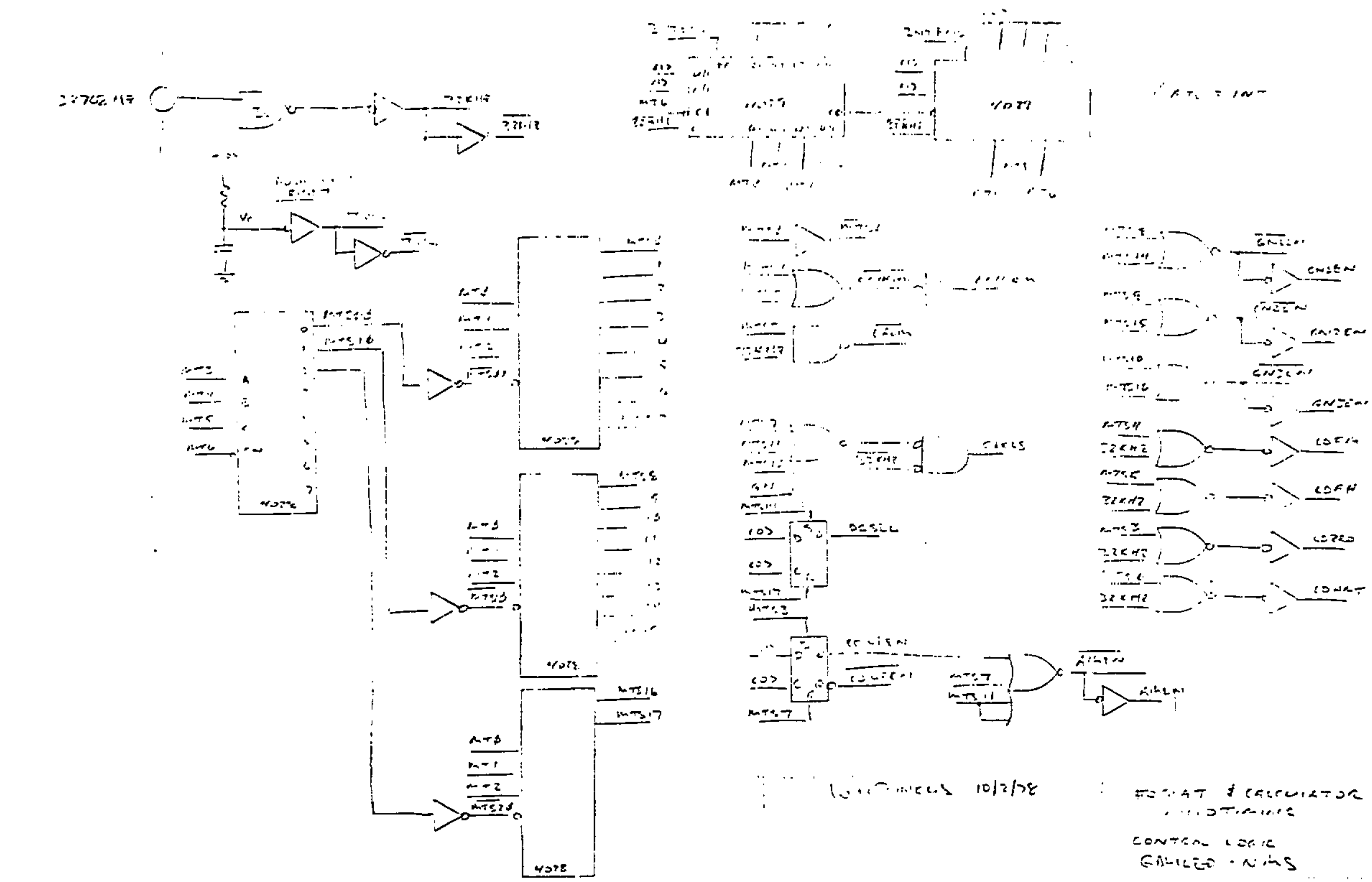


NOTES
- UNLESS OTHERWISE INDICATED -
1 - ALL RESISTORS IN OHMS ±5% COMP
2 - ALL DIODES IN4148
3 - NUMBER OF WINDINGS
READ = 4
WRITE = 4
SENSE = 1
4 - ALL CORES
OUTER DIAMETER 57 MILLS
INNER DIAMETER 35 MILLS
THICKNESS 20 MILLS
5 - ALL TRANSISTORS 2N2222A

ENGINEER W H PINKUS 5-8-78	DRAFTSMAN P D 5-11-78		
SPACE PHYSICS RESEARCH LABORATORY COLLEGE OF ENGINEERING UNIVERSITY OF MICHIGAN ANN ARBOR, MICHIGAN	COMMAND MEMORY CONTROL LOGIC GALILEO ~~EPD~~ NMS	6-24-78	
	B-E4472	DATE	

LAST USED R C D L

7.4



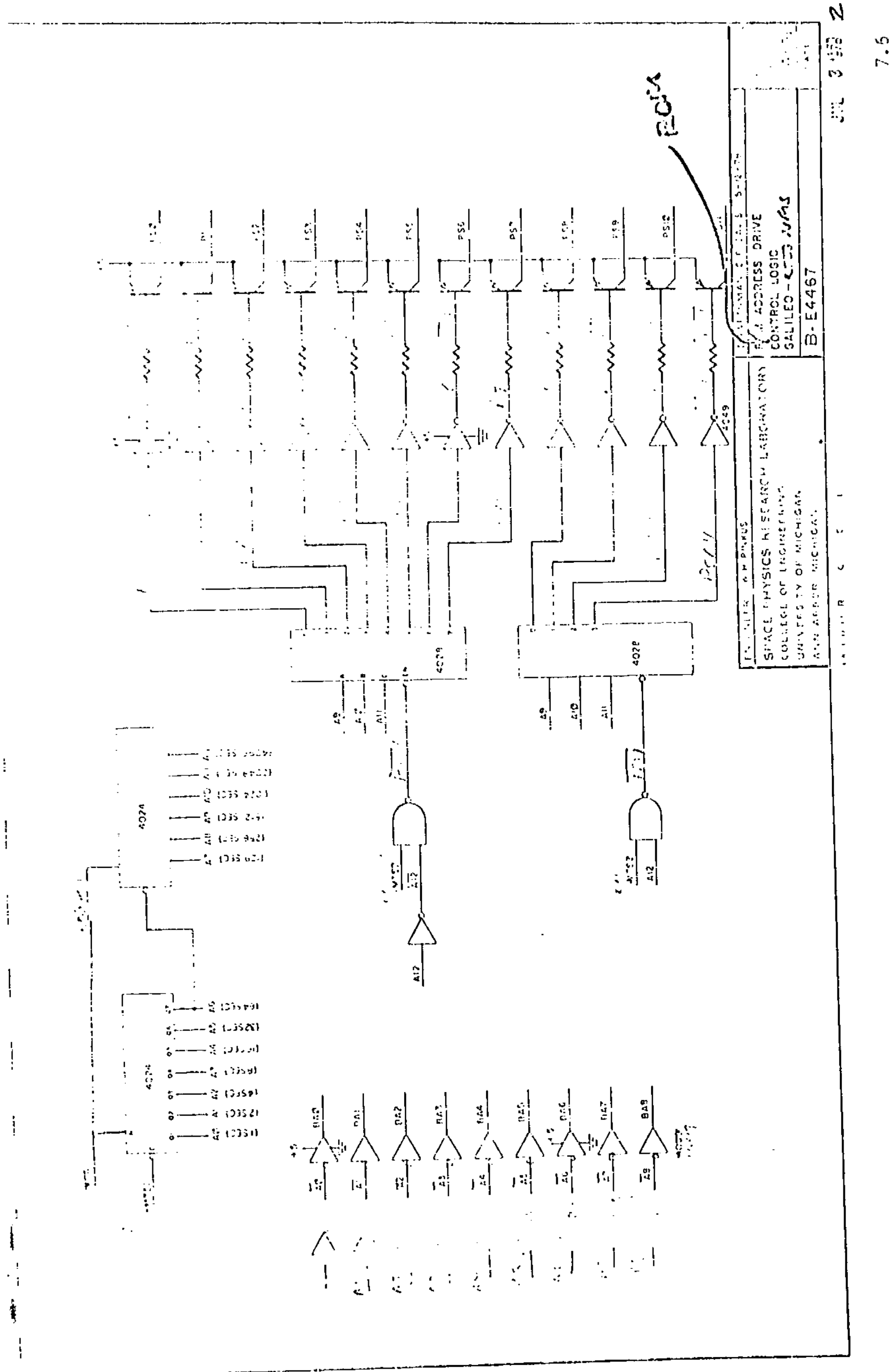
10/2/78

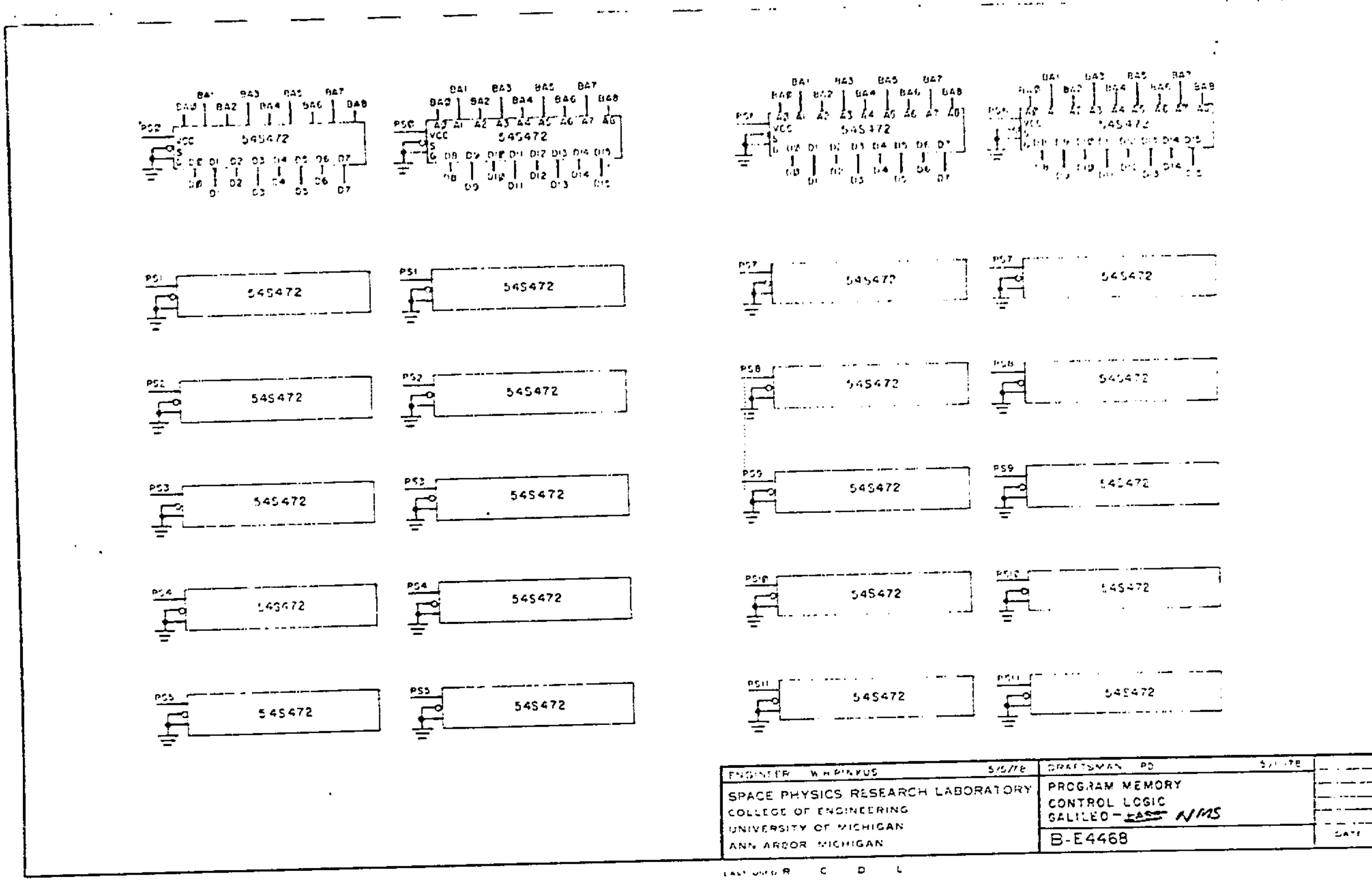
FORMAT & CALCULATOR

CONTROL LOGIC
GALILEO · NIMS

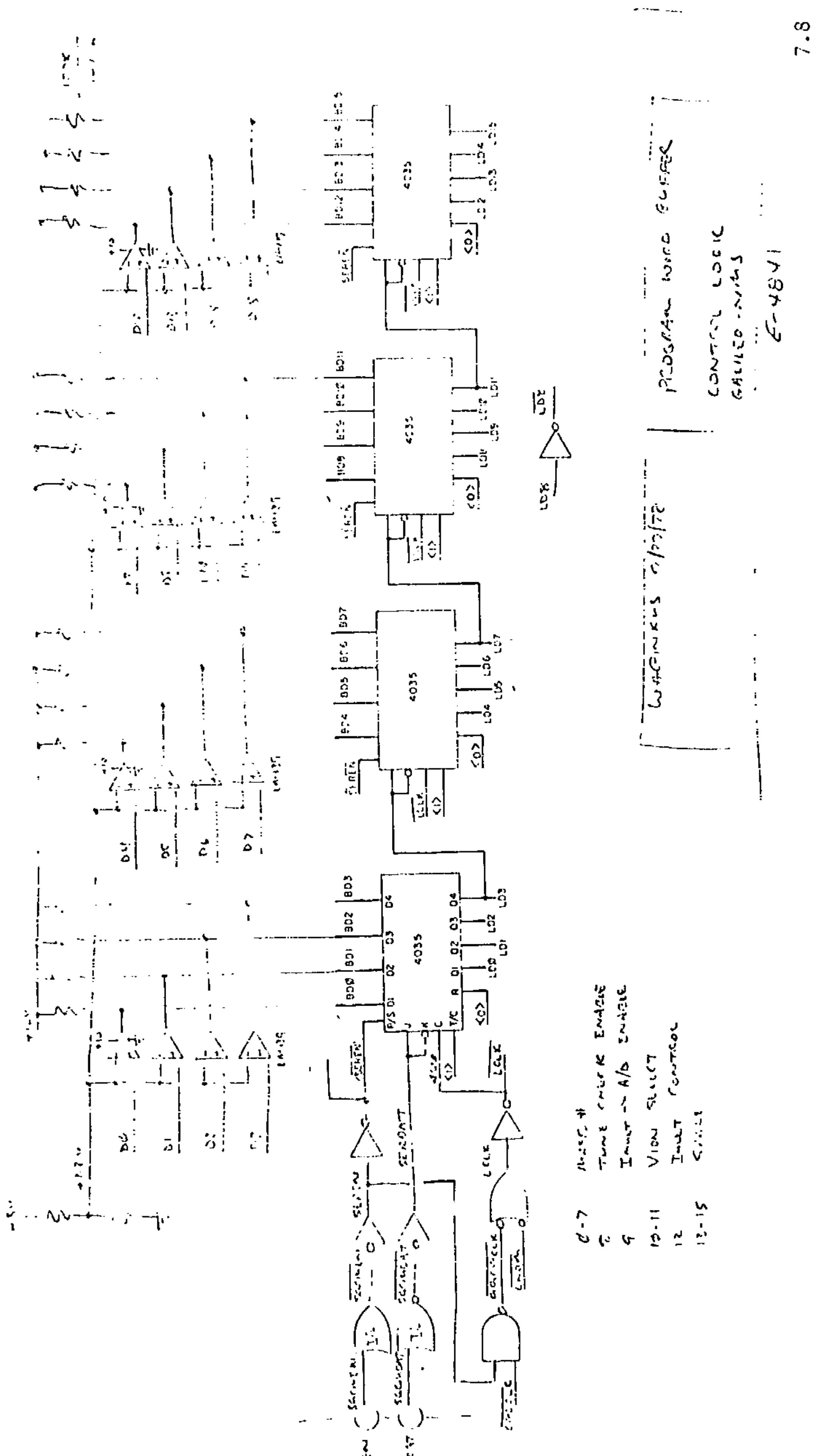
E-4840

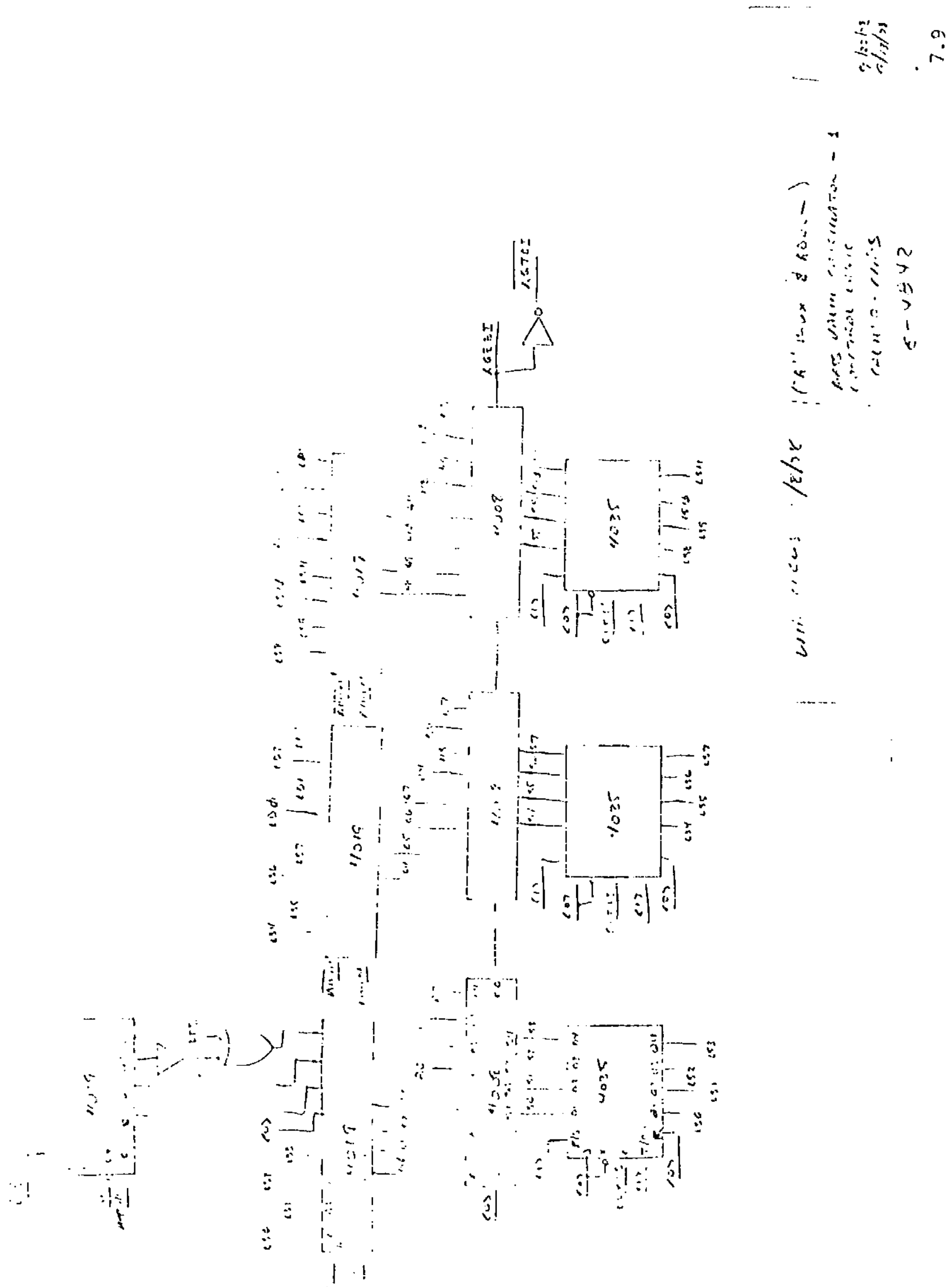
7.5

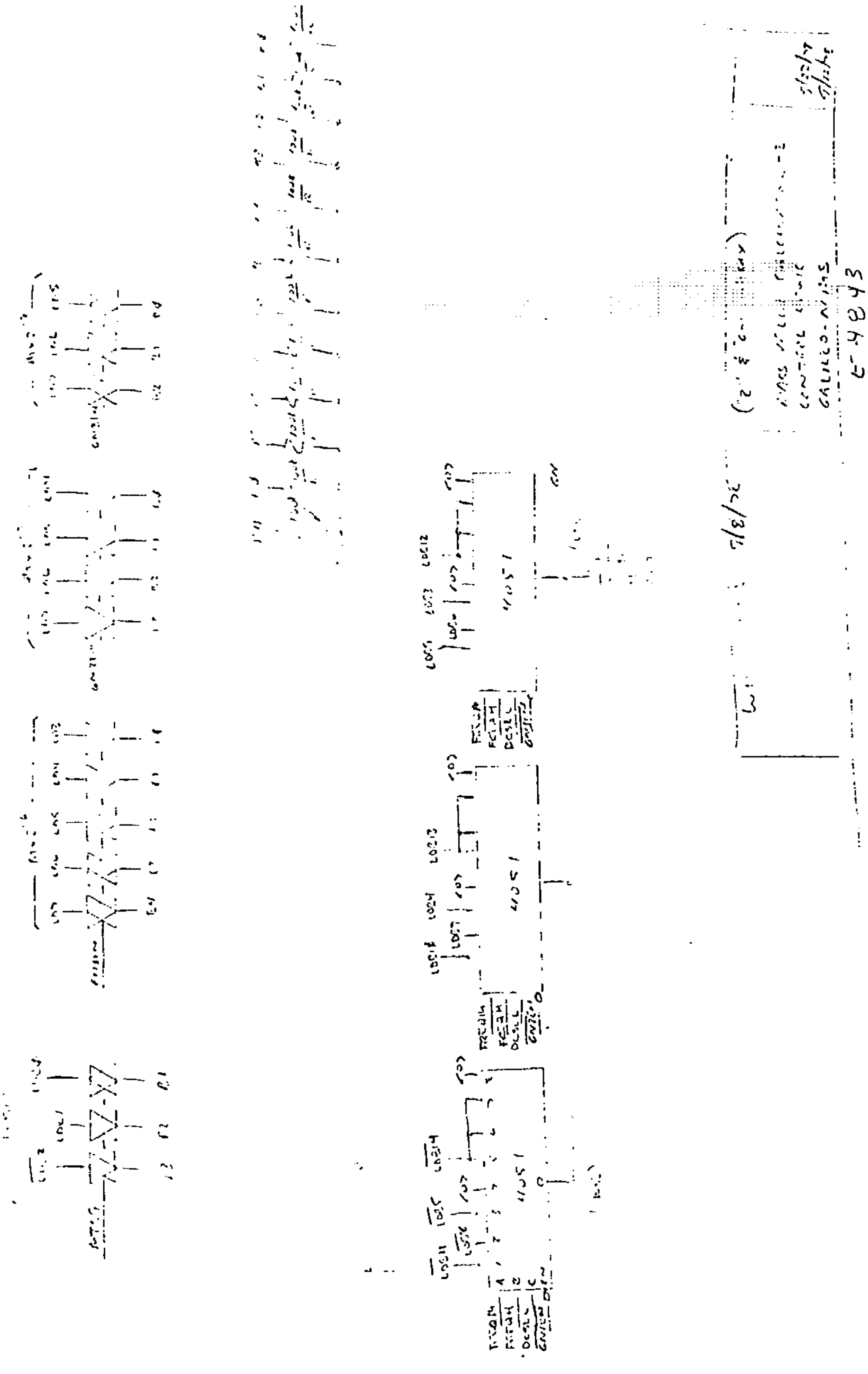

SPACE PHYSICS RESEARCH LABORATORY
COLLEGE OF ENGINEERING
UNIVERSITY OF MICHIGAN
ANN ARBOR MICHIGAN
ADDRESS DRIVE
CONTROL LOGIC
GALILEO
B-E4467
4028
4024
4049
7.5


54S472
PS1
PS2
PS3
PS4
PS5
PS7
PS8
PS9
PS10
PS11
ENGINEER W. H. PINKUS 5/5/78
DRAFTSMAN PD
SPACE PHYSICS RESEARCH LABORATORY
COLLEGE OF ENGINEERING
UNIVERSITY OF MICHIGAN
ANN ARBOR MICHIGAN
PROGRAM MEMORY
CONTROL LOGIC
GALILEO - ~~EASS~~ NMS
B-E4468
DATE
R C D L

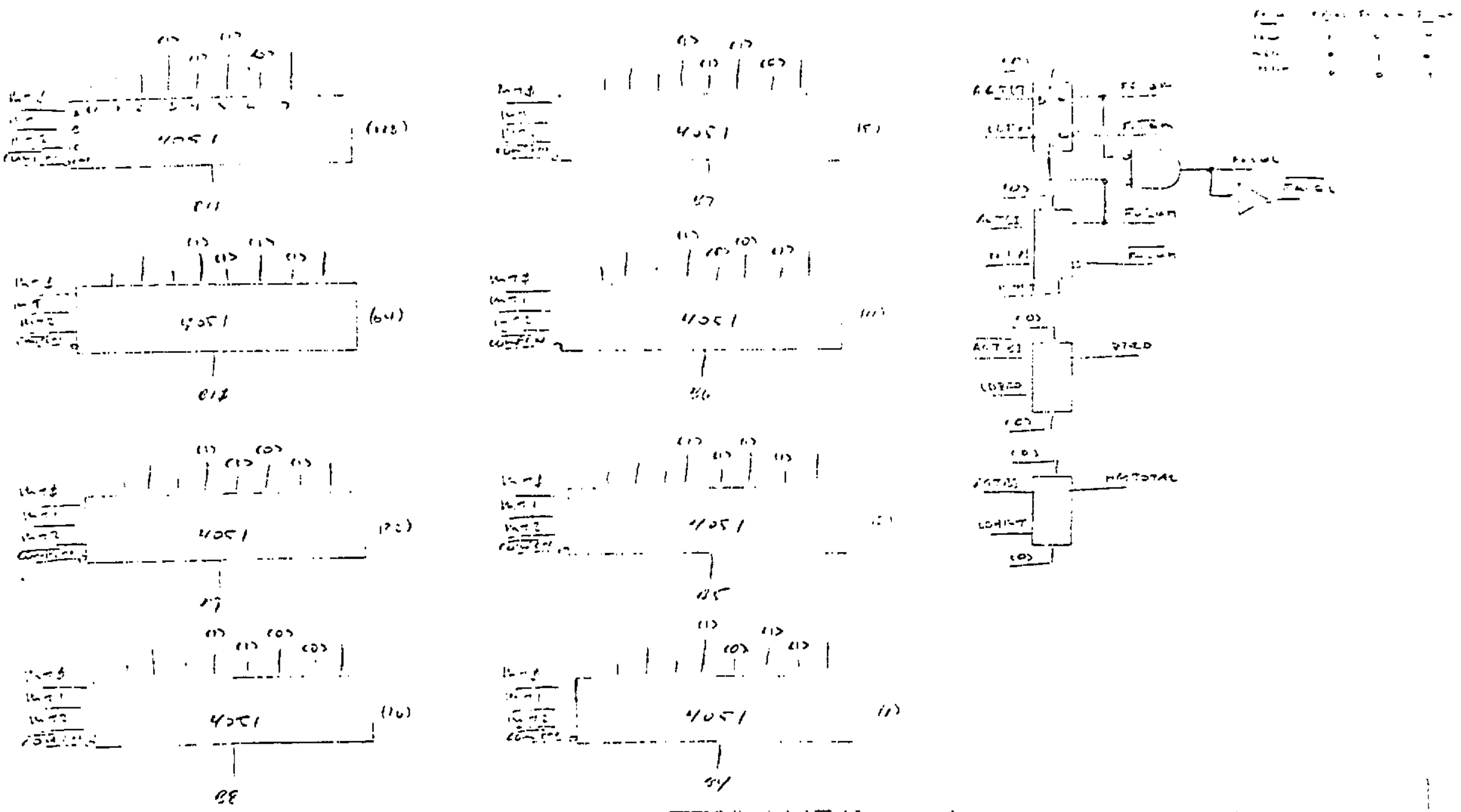
7.7


4035
4035
4035
4035
PROGRAM WORD BUFFER
CONTROL LOGIC
GALILEO-NIMS
E-48V1
7.8





7.10

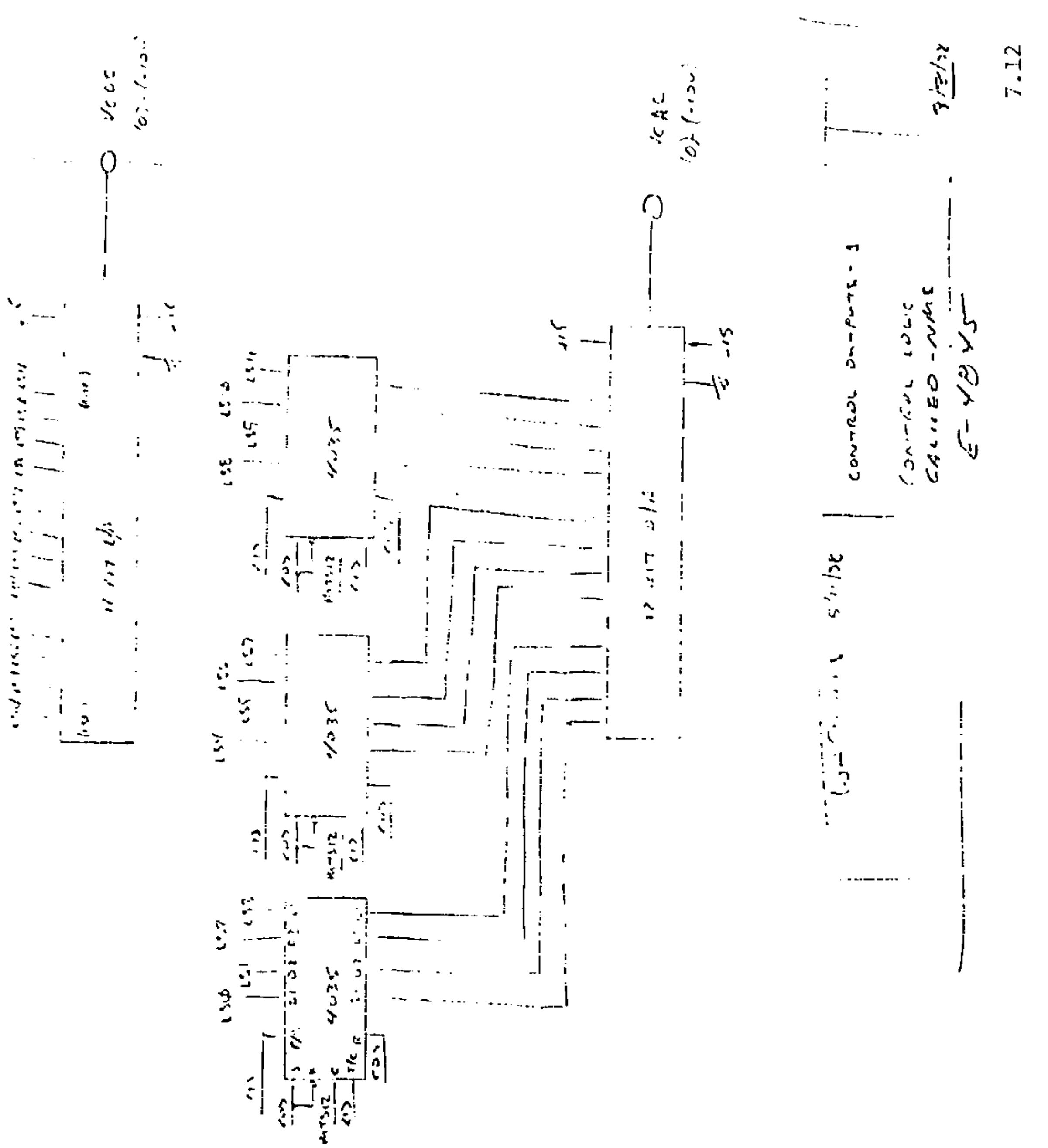


W. REINKES 7/22/82

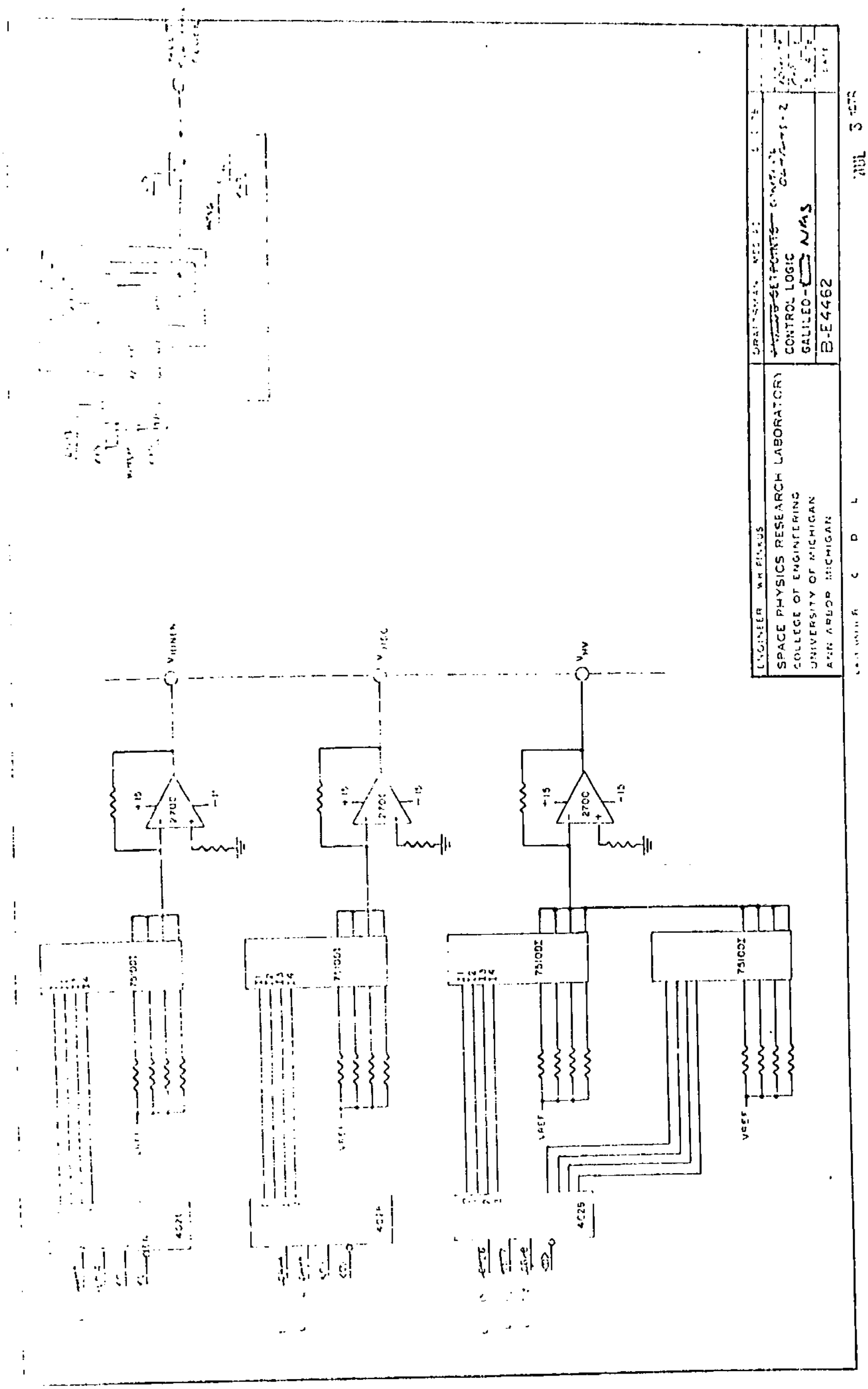
(COMPARISON VALUE MULTIPLEXER)
MASS VALUE CALCULATOR-3
CONTROL LOGIC
GALILEO-NMS

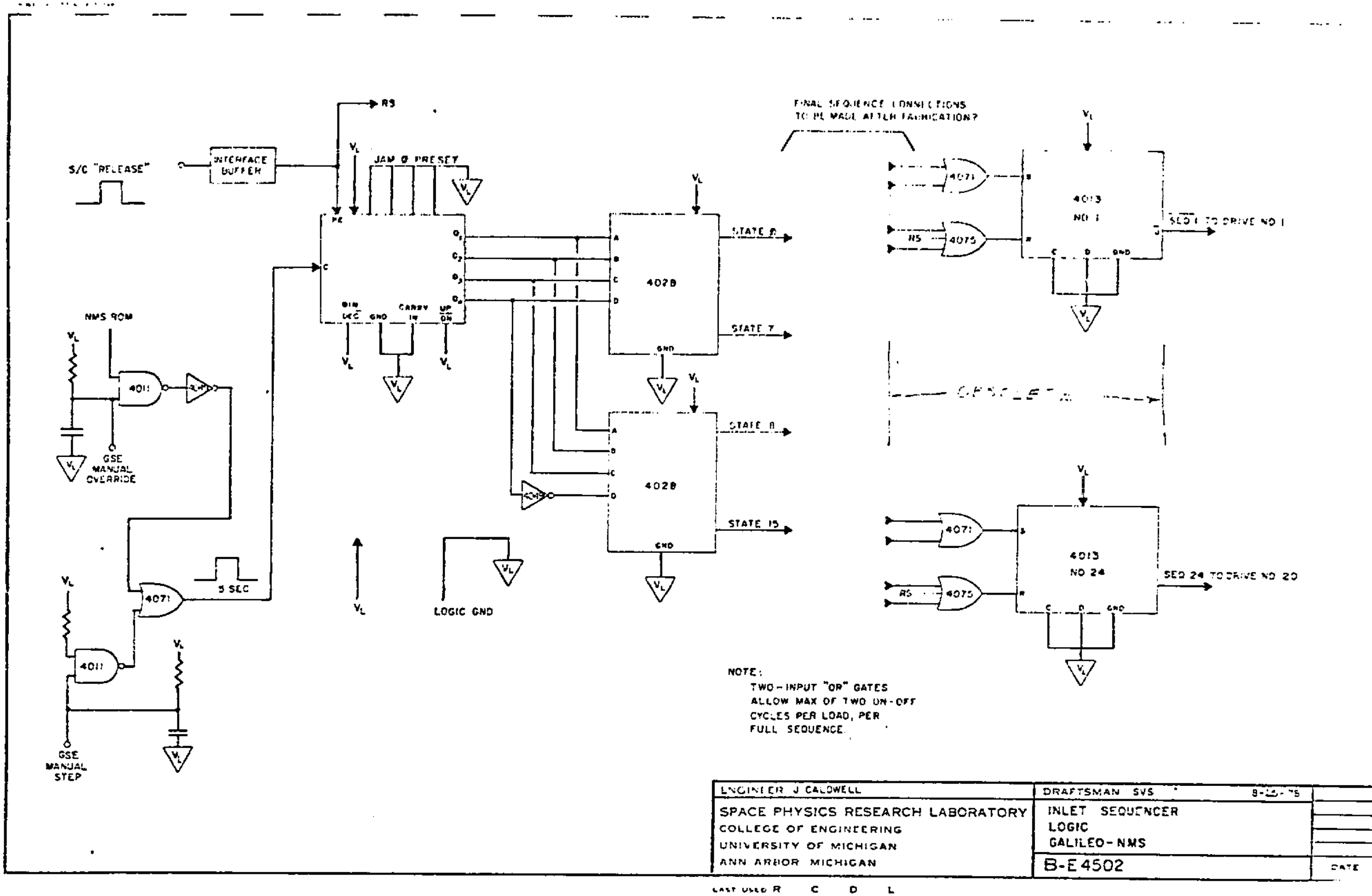
6-4844

7.11


4035
7.12

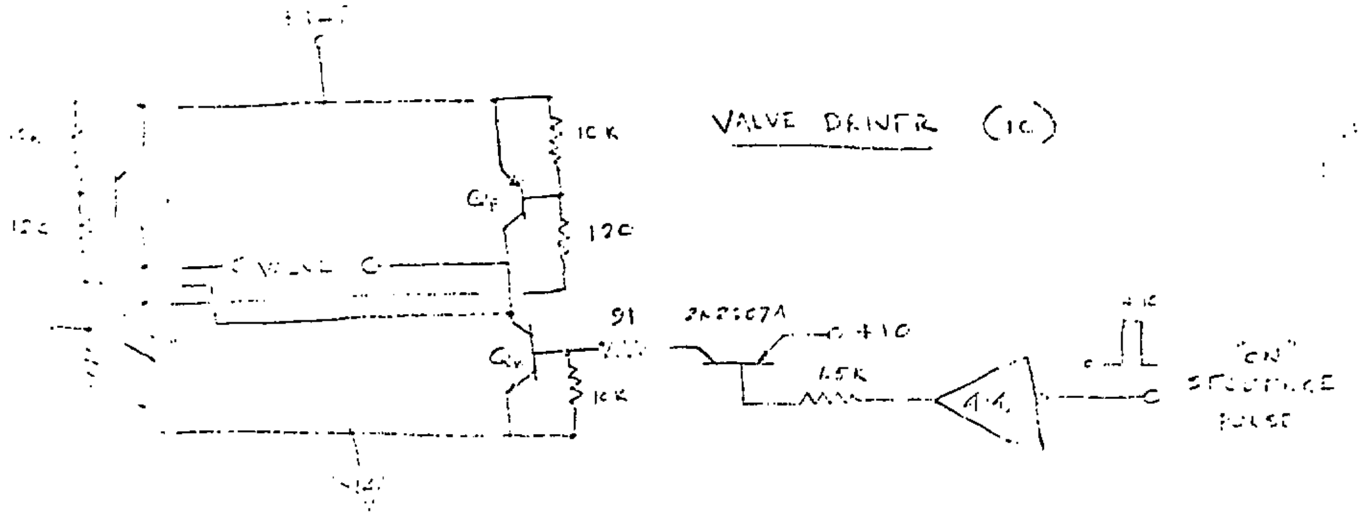
7.13

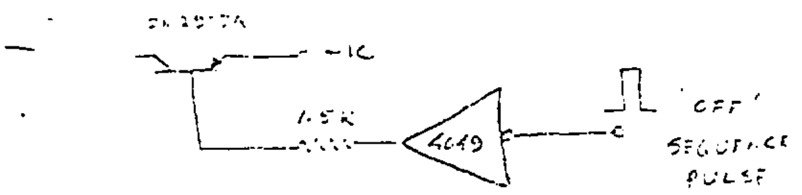

SPACE PHYSICS RESEARCH LABORATORY
COLLEGE OF ENGINEERING
UNIVERSITY OF MICHIGAN
ANN ARBOR MICHIGAN
CONTROL LOGIC
GALILEO
B-E4462
751002
2700
4025


S/C "RELEASE"
INTERFACE BUFFER
RS
JAM Ø PRESET
NMS ROM
4011
GSE MANUAL OVERRIDE
4071
5 SEC
GSE MANUAL STEP
LOGIC GND
4028
STATE 0
STATE 7
STATE 8
STATE 15
FINAL SEQUENCE CONNECTIONS TO BE MADE AFTER FABRICATION?
4075
4013 NO 1
SEQ 1 TO DRIVE NO 1
4013 NO 24
SEQ 24 TO DRIVE NO 20
NOTE:
TWO-INPUT "OR" GATES ALLOW MAX OF TWO ON-OFF CYCLES PER LOAD, PER FULL SEQUENCE.
ENGINEER J CALDWELL
SPACE PHYSICS RESEARCH LABORATORY
COLLEGE OF ENGINEERING
UNIVERSITY OF MICHIGAN
ANN ARBOR MICHIGAN
DRAFTSMAN SVS
INLET SEQUENCER
LOGIC
GALILEO-NMS
B-E4502
DATE
LAST USED R C D L

S.1

VALVE DRIVER (1C)





AND Q_n ARE TO BE SELECTED
VERIDIZING, THEY SHOULD BE RATED
AMP/10 MSEC PULSES.

CIRCUITS TO BE DESIGNED

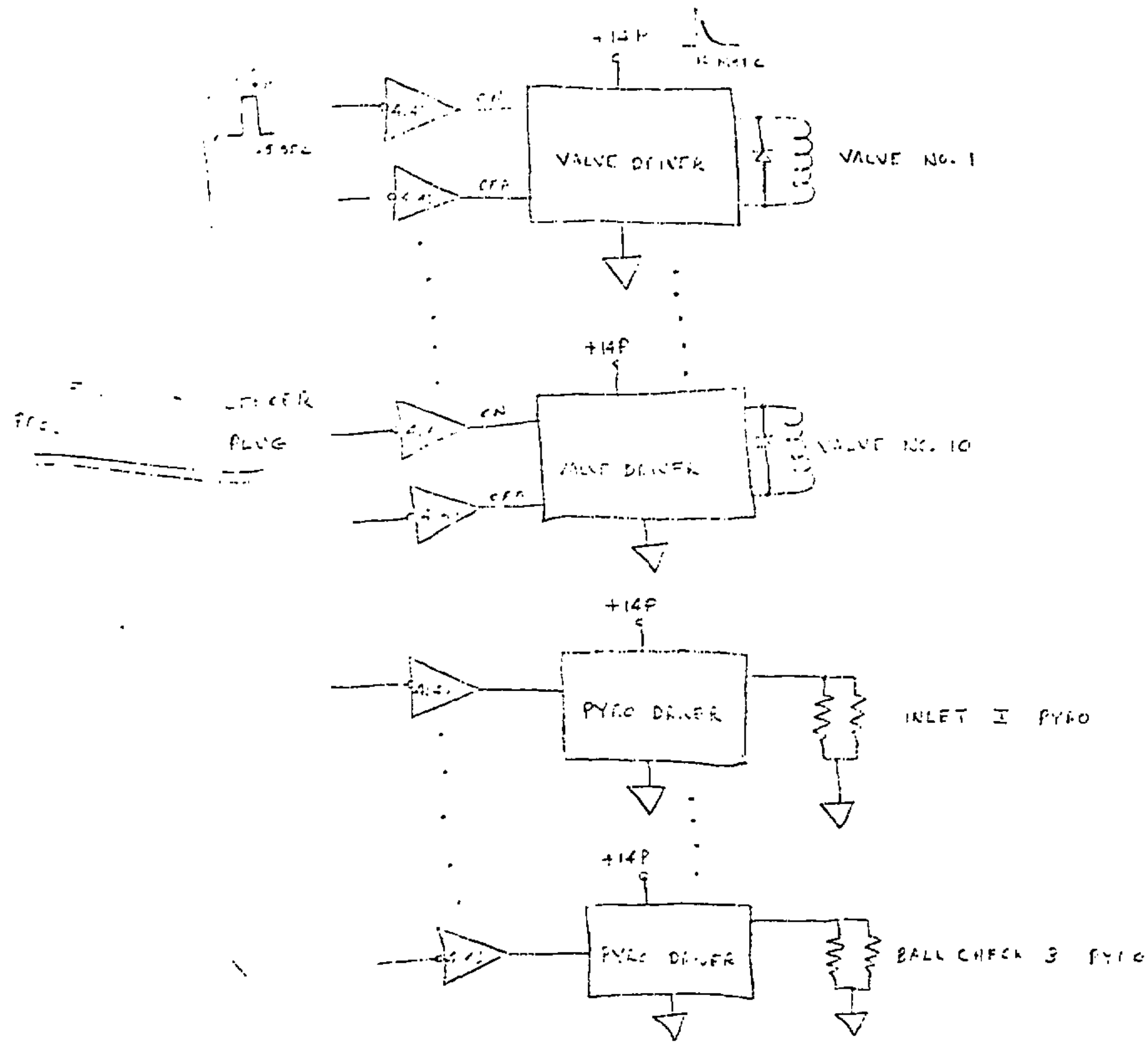
1. HEATER DRIVER
2. FILAMENT SELECT
3. OVEN TEMPERATURE CONTROL
4. STATUS MONITORS

INLET SEQUENCER

DRIVE CIRCUITS
B-E 4501
CANCELLED

10-12-76

S.2



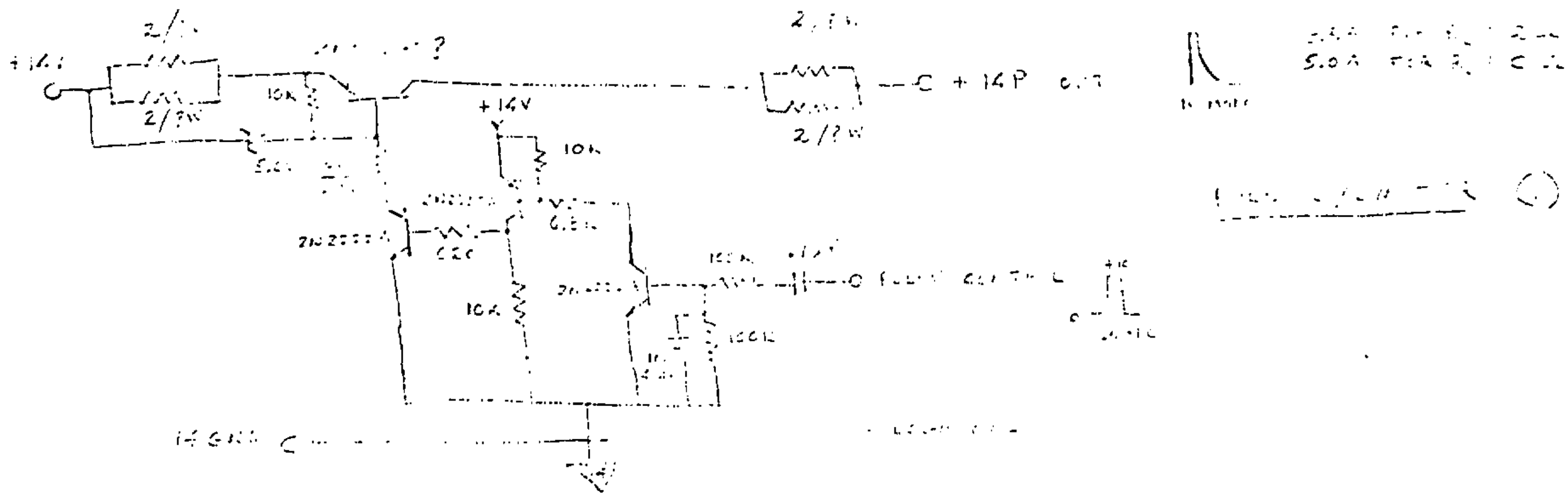
NOTE: DIODES WILL BE SPECIFIED IF AT ..., HYBRIDIZED OTHERWISE, SHOULD HAVE 1.5 AMP DERATING.

B-E 4218

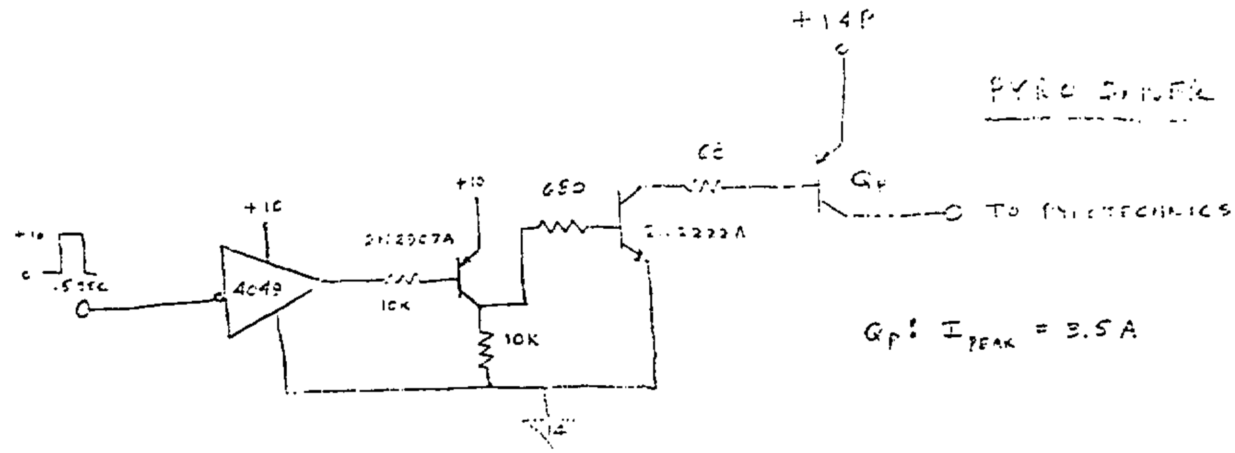
INLET SEQUENCER

DRIVE BLOCKS

8.3

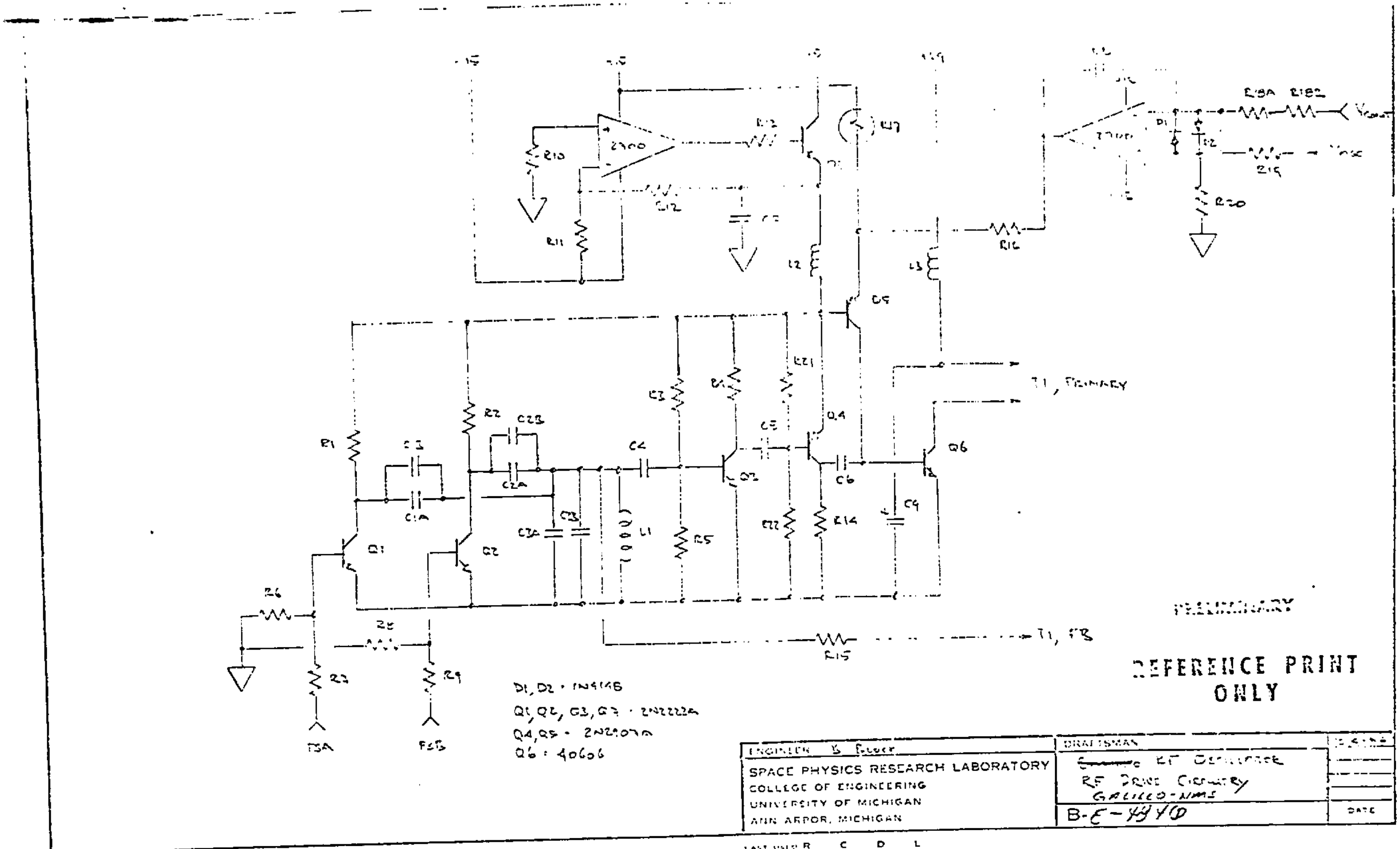


PYRO DRIVER (number required ?)

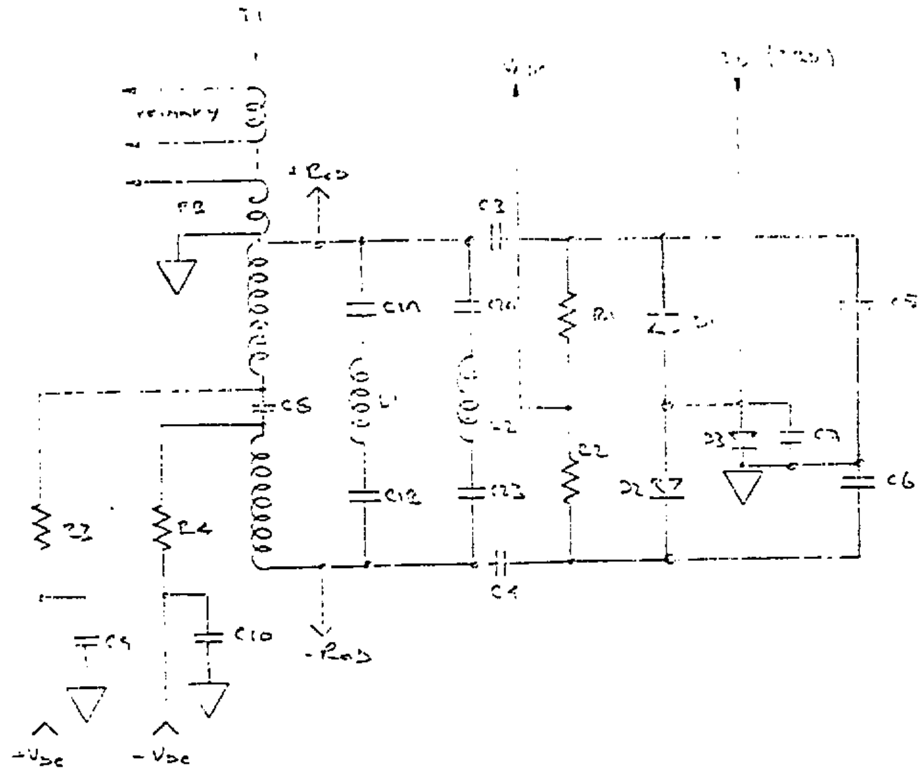


~~[illegible]~~ INLET SEQUENCER
DRIVE CIRCUITS
B-E4817
CALDWELL 11-12-73

S.4



D1, D2 · 1N4148
Q1, Q2, Q3, Q7 · 2N2222A
Q4, Q5 · 2N2907A
Q6 · 40606
T1, PRIMARY
T1, FB
PRELIMINARY
REFERENCE PRINT
ONLY
SPACE PHYSICS RESEARCH LABORATORY
COLLEGE OF ENGINEERING
UNIVERSITY OF MICHIGAN
ANN ARBOR, MICHIGAN
RF Drive Circuitry
GALILEO-NMS
B-E-4340
10.1



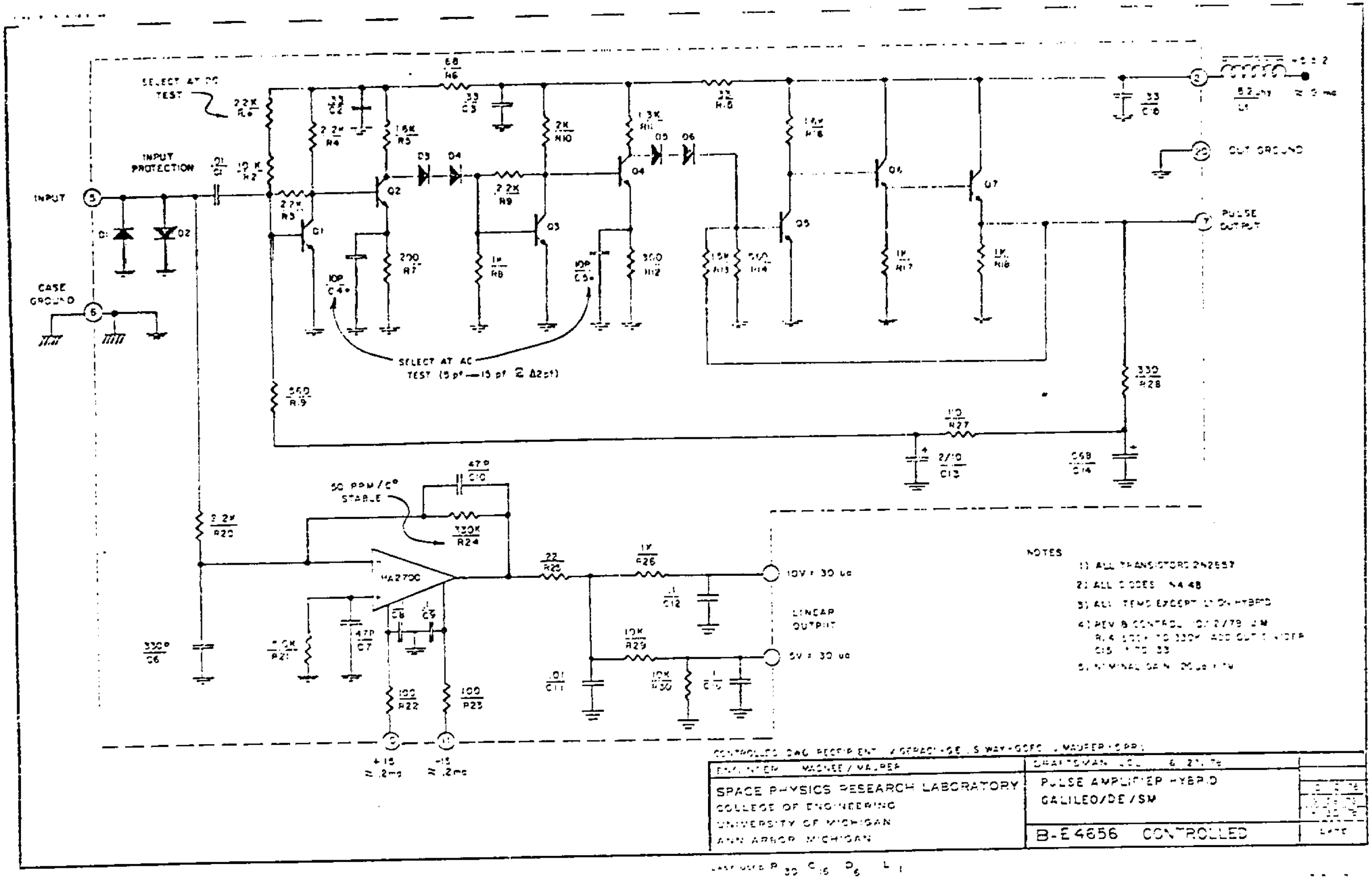
D1, D2, D3 = 1N5711

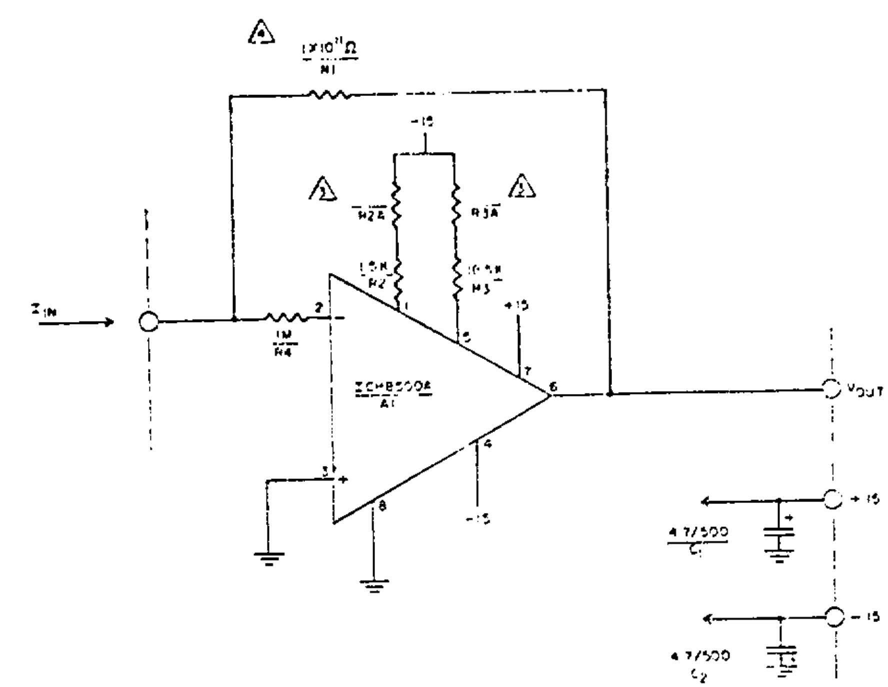
PRELIMINARY

REFERENCE PRINT
ONLY

ENGINEER	CRAFTSMAN
SPACE PHYSICS RESEARCH LABORATORY COLLEGE OF ENGINEERING UNIVERSITY OF MICHIGAN ANN ARBOR MICHIGAN	
	B-E-1847

10.2


INPUT
CASE GROUND
INPUT PROTECTION
SELECT AT DC TEST
SELECT AT AC TEST (5 pf — 15 pf ≅ Δ2pf)
PULSE OUTPUT
OUT GROUND
50 PPM/C° STABLE
HA2700
LINEAR OUTPUT
10V ± 30 ua
5V ± 30 ua
+15 ≈ .2ma
-15 ≈ .2ma
NOTES
1) ALL TRANSISTORS 2N2857
SPACE PHYSICS RESEARCH LABORATORY
COLLEGE OF ENGINEERING
UNIVERSITY OF MICHIGAN
ANN ARBOR MICHIGAN
PULSE AMPLIFIER HYBRID
GALILEO/DE/SM
B-E4656 CONTROLLED



NOTES (UNLESS OTHERWISE INDICATED)

1. ALL CAPS IN MICROFARADS
2. ALL RESISTANCES IN OHM ±5% COMP
3. SELECT VALUE AT TEST
4. R1 VICTOREEN HIGH MEG TYPE RX-1, ±2%

ENGINEER A. W. RIGGWAY / W. H. PINKUS — DRAFTSMAN MSS 9-26-75

SPACE PHYSICS RESEARCH LABORATORY
COLLEGE OF ENGINEERING
UNIVERSITY OF MICHIGAN
ANN ARBOR MICHIGAN

GRID ELECTROMETER
GALILEO - NMS

B-E4749

DATE

LAST USED R C D L

II.2

ACCUMULATOR CONTENTS / EXPONENT / FRACTION

BIT #:	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	EXPONENT 3	2	1	0	FRACTION (9)	8	7	6	5	4	3	2	1	0
	1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	1	1	1	1	(1)	22	21	20	19	18	17	16	15	14
	0	1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	1	1	1	0	(1)	21	20	19	18	17	16	15	14	13
	0	0	1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	1	1	0	1	(1)	20	19	18	17	16	15	14	13	12
	0	0	0	1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	1	1	0	0	(1)	19	18	17	16	15	14	13	12	11
	0	0	0	0	1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	1	0	1	1	(1)	18	17	16	15	14	13	12	11	10
	0	0	0	0	0	1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	1	0	1	0	(1)	17	16	15	14	13	12	11	10	9
	0	0	0	0	0	0	1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	1	0	0	1	(1)	16	15	14	13	12	11	10	9	8
	0	0	0	0	0	0	0	1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	1	0	0	0	(1)	15	14	13	12	11	10	9	8	7
	0	0	0	0	0	0	0	0	1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	0	1	1	1	(1)	14	13	12	11	10	9	8	7	6
	0	0	0	0	0	0	0	0	0	1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	0	1	1	0	(1)	13	12	11	10	9	8	7	6	5
	0	0	0	0	0	0	0	0	0	0	1	x	x	x	x	x	x	x	x	x	x	x	x	x	0	1	0	1	(1)	12	11	10	9	8	7	6	5	4
	0	0	0	0	0	0	0	0	0	0	0	1	x	x	x	x	x	x	x	x	x	x	x	x	0	1	0	0	(1)	11	10	9	8	7	6	5	4	3
	0	0	0	0	0	0	0	0	0	0	0	0	1	x	x	x	x	x	x	x	x	x	x	x	0	0	1	1	(1)	10	9	8	7	6	5	4	3	2
	0	0	0	0	0	0	0	0	0	0	0	0	0	1	x	x	x	x	x	x	x	x	x	x	0	0	1	0	(1)	9	8	7	6	5	4	3	2	1
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	x	x	x	x	x	x	x	x	x	0	0	0	1	(1)	8	7	6	5	4	3	2	1	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	x	x	x	x	x	x	x	x	0	0	0	0	(0)	8	7	6	5	4	3	2	1	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	x	x	x	x	x	x	x	0	0	0	0	(0)	8	7	6	5	4	3	2	1	0

DECODING TRANSFER FUNCTION

IF E = 0: V = F, ERROR BAR = ± 0.5.

IF E ≠ 0: $V = (512 + F) \times 2^{(E-1)} + 2^{(E-2)} - 0.5$, ERROR BAR = $\pm 2^{(E-2)}$.

WHERE: E = EXPONENT
F = FRACTION
V = RECONSTRUCTION OF THE ORIGINAL ACCUMULATED SUM.

ENGINEER W. H. PINKUS	DRAFTSMAN CPP 1-5-75
SPACE PHYSICS RESEARCH LABORATORY COLLEGE OF ENGINEERING UNIVERSITY OF MICHIGAN ANN ARBOR MICHIGAN	FLOATING-POINT CONVERSION TABLE DATA PROCESSING LOGIC GALILEO-NMS
	B- E 4513

LAST USED R C D L

17.1

3. PARTS LISTS

PROJECT PARTS AND MATERIALS RATING

NASA-AMES RESEARCH CENTER
MOFFETT FIELD, CALIFORNIA 94035

PROJECT SAL[illegible]
CONTRACTOR University of Mich.
CONTRACT NUMBER [illegible]

PAGE
DATE 09/18/78
REVISION

ITEM NO.	REV	PART, DEVICE, MATERIAL GENERIC NAME	PROCUREMENT DESIGNATION	MANUFACTURER	PROCUREMENT SPECIFICATION	SCREENING SPECIFICATION	NASA RATING ITEM	NASA RATING SCR. SPEC.
		CMOS	CD4001AH/1NZ	RCA	MIL-M-38510/52	GS-201		
		CMOS	CD4008AH/1NZ	RCA	MIL-M-38510			
		CMOS	CD4011AH/1NZ	RCA	MIL-M-38510/50			
		CMOS	CD4013AH/1NZ	RCA	MIL-M-38510/51			
		CMOS	CD4016AH/1NZ	RCA				
		CMOS	CD4023AH/1NZ	RCA	MIL-M-38510/50			
		CMOS	CD4024AH/1NZ	RCA	MIL-M-38510/56			
		CMOS	CD4028AH/1NZ	RCA				
		CMOS	CD4029AH/1NZ	RCA				
		CMOS	CD4035AH/1NZ	RCA				
		CMOS	CD4049AH/1NZ	RCA	MIL-M-38510/55			
		CMOS	CD4050AH/1NZ	RCA	MIL-M-38510/55			
		CMOS	CD4051BH/1NZ	RCA				
		CMOS	CD4063BH/1NZ	RCA				
		CMOS	CD4071BH/1NZ	RCA				
		CMOS	CD4075BH/1NZ	RCA				
		CMOS	CD40109BH/1NZ	RCA				
		Microprocessor	CDP1802H/1NZ	RCA				
		ROM	CDP1834H/1NZ	RCA				
		Encoder	CD4332BH/1NZ	RCA				

REMARKS:

PREVIOUS EDITIONS OF THIS FORM ARE OBSOLETE.

ARC 23 (REV MAY 74)

GPO 74 79?-505/596

PROJECT PARTS AND MATERIALS RATING

NASA-AMES RESEARCH CENTER
MOFFETT FIELD, CALIFORNIA 94035

PROJECT ILE

CONTRACTOR University of Mic

CONTRACT NUMBER NAS5-24454

DATE

REVISION

ITEM NO.	REV	PART, DEVICE, MATERIAL GENERIC NAME	PROCUREMENT DESIGNATION	MANUFACTURER	PROCUREMENT SPECIFICATION	SCREENING SPECIFICATION	NASA RATING ITEM	NASA RATING SCR. SPEC.
		CMOS	MN5251 H/B	Micronetworks		GS-201		
		Transistor	JANTXV2N2907A	Motorola	MIL-S-19500/291			
		Transistor	JANTXV2N3743	Motorola	MIL-S-19500/397			
		Transistor	JANTXV2N3499	Motorola	MIL-S-19500/366			
		Transistor	JANTXV2N2222A	Motorola	MIL-S-19500/225			
		Transistor	JANTX2N4405	Motorola	MIL-S-19500/448			
		Transistor	JANTX2N5005	TI				
		Diode	JANTXV1N974B	Motorola	MIL-S-19500/117			
		Diode	JANTXV1N4148	TI	MIL-S-19500/116			
		Transistor	2N3632	RCA	RCA-40606			
		Diode	JANTXV1N5711	HP	MIL-S-19500/444			
		Diode	JANTXV1N4946	Semtech	MIL-S-19500/359			
		Diode	JANTX1N914		MIL-S-19500/116			
		Transistor	JANTXV2N2857	RCA	MIL-S-19500/343			
		OP-AMP	G-2700(HA-2700)	Harris	GSFCS-311-P-32(10)			
		Multiplexer	HI506-A	Harris				
		Switch	AD7510DIKN	Analog Devices				
		TTL	SN74S472	TI				
		Switch	DG201CJ	Siliconix				

REMARKS:

ARC 23 (REV MAY 74) PREVIOUS EDITIONS OF THIS FORM ARE OBSOLETE. ☆G.P.O. '74 794-005/596

PROJECT PARTS AND MATERIALS [illegible]

PROJECT ALI[illegible]

NASA-AMES RESEARCH CENTER
MOFFETT FIELD, CALIFORNIA 94035

CONTRACTOR University of Mich.

CONTRACT NUMBER [illegible]5-24454

DATE 9/18/73

REVISION

ITEM NO.	REV	PART, DEVICE, MATERIAL GENERIC NAME	PROCUREMENT DESIGNATION	MANUFACTURER	PROCUREMENT SPECIFICATION	SCREENING SPECIFICATION	NASA RATING	
							ITEM	SCR. SPEC
		OP-AMP	IC8500ATV	Intersil		GS-291		
		Coil, RF	M39010/0*-A***KP	39010 QPL	MIL-C-39010			
		Resistor,Carbon	RCR05G***JS	39008 QPL	MIL-R-39008			
		Resistor,Carbon	RCR07G***JS	39008 QPL	MIL-R-39008			
		Resistor, Carbon	RCR20G***JS	39008 QPL	MIL-R-39008			
		Resistor,Carbon	RCR32G***JS	39008 QPL	MIL-R-39008			
		Resistor,MF	RNC50J****FS	55182QPL	MIL-R-55182			
		Resistor,MF	RNC55J****FS	55182QPL	MIL-R-55182			
		Resistor,MF	RNC60J****FS	55182QPL	MIL-R-55182			
		Resistor,MF	RNC65J****FS	55182QPL	MIL-R-55182			
		Resistor,MOF	MOX400A	Victoreen	MOX400A			
		Thermistor	311P18-***	Yellow Springs	S-311-P-18			
		Sensistor	TM1/4	TI	TM 1/4			
		Resistor,WW	RBR53L***** BS	39005 QPL	MIL-R-39005			
		Resistor,WW	RBR74L***** BS	39005 QPL	MIL-R-39005			
		Cap,Cer,CKR05	M39014/01-****	39014 QPL	MIL-C-39014			
		Cap,Cer,CKR06	M39014/02-****	39014 QPL	MIL-C-39014			
		Cap,Tan,CSR13	M39003/01-****	39003 QPL	MIL-C-39003			
		Cap,Por,CYR42,43	M23269/09-****	23269 QPL	MIL-C-23269			
		Cap,Por,CYR53	M23269/10-****	23269 QPL	MIL-C-23269			

REMARKS:

ARC 22 (REV MAY 74)

PREVIOUS EDITIONS OF THIS FORM ARE OBSOLETE.

GPO 74 [illegible]

PROJECT PARTS AND MATERIALS RATING

NASA-AMES RESEARCH CENTER
MOFFETT FIELD, CALIFORNIA 94035

CONTRACTOR Univ of Michigan

CONTRACT NUMBER NAS 2-24154

DATE 1 / / 73

REVISION

ITEM NO.	REV	PART, DEVICE, MATERIAL GENERIC NAME	PROCUREMENT DESIGNATION	MANUFACTURER	PROCUREMENT SPECIFICATION	SCREENING SPECIFICATION	NASA RATING ITEM	NASA RATING SCR. SPEC
		Solder	6440 rosin core 66	Kester				
		Wire	19XXTW10	Tensolite	MIL-W-16878/D			
		Stitch Wire	700501	Moore Systems	700501			
		PC Boards						
		Core	T-80 -7	Micrometals		Visual		
		Core	T-130-7	Micrometals		Visual		
		Core	T-157-7	Micrometals		Visual		
		Connector	G311P10 - ** - C12	ITT or TRW	GSFC-311-P-10			
		Lacing Cord	20 DPT - H	Gudebrod				
		Heat shrink tubing	Kyrar M22	Raychem				

REMARKS:

ARC 20 (REV MAY 74)

PREVIOUS EDITIONS OF THIS FORM ARE OBSOLETE.

G.P.O. 74 794-555/576

4. DESIGN NOTES

J. Maurer

W. Pinkus 5/12/78

Description of Galileo-LASS Preliminary Logic Design

Major subsystems of the logic design for Galileo-LASS are the Program Sequence Generator, the Command Memory, the Mass Control Processor, the Pulse Counter, and the Analog Multiplexer and the A/D Converter.

The Program Sequence Generator consists of a 13-bit counter incremented at half-second intervals, an array of Read-Only Memory (ROM) devices to produce a 6144 word, 16-bit look-up table, and an output storage register to hold the 16-bit word actually being used to define instrument function. When the signal defining the end of the half-second integration period occurs, a series of pulses are generated. The first increments the Program Counter, the second enables the ROM, the next strobes the ROM output value into the buffer register, the fourth starts the Mass Control Processor, and the fifth turns off the pulse generator. At power turn-on, the counter is cleared and a flip-flop is set which holds the upper end of the program counter reset until being cleared by a pulse from the space craft. The result is that the instrument will continue to cycle through its first 64 seconds of program from power turn-on until being released to start the "science" mission. I intend that this first 64 seconds should constitute tuning checks, etc. The ROM array is shown as an array of 512 x 8 Shottkey-TTL devices which are of the fuse-blowing variety for programming. Use

what happens when a power failure?

of the RCA CDP 1832 1024 x 8 mask-programmed ROMs would cut the size and complexity of this system, but would highly probably cost more for the piece parts and would also have a longer lead-time. Neither choice is currently an approved part, although both are on the Project's "Wish List." The storage register has a serial input to allow overriding the normal program sequence with the instrument GSE. The 16 bits of program word are allocated as follows:

8 bits: Mass Select
(bottom 4 bits also drive the Analog Multiplexer)

3 bits: Data Output Control
a) Multiplexer or Log Amp to A/D converter
b) A/D conversion enable
c) Digital Data or Analog Data to telemetry

1 bit: Increment Inlet Control Sequencer

1 bit: Filament On/Off

2 bits: Ionization Energy Select

1 bit: Spare

An 8-bit digital comparator is provided to look at the Mass Select bits and determine is the value is above or below the High Frequency/Low Frequency transition value.

The Command Memory consists of a 32-bit shift register, a 32-bit core memory, and control logic. Appearance of a Command Enable signal overrides all other functions and sets up the shift register to load new command data from the spacecraft. Disappearance of the Command Enable initiates data "write" cycle to the core memory. Power turn-on initiates a data "read" cycle. Cores are accessed one at a time, requiring use of only one sense amplifier and minimizing the energy in the read/write drive pulses. Individual drive

is used for each core, which should result in loosened tolerance on operating parameter requirements as compared to a more convention coincident-drive system. During core read/write cycles the contents of the shift register are shifted along to present each bit to the drive circuits serially. In the "read" mode, a "read" pulse is applied to a core and the response is stored in a flip-flop. The content of the flip-flop is loaded into the shift register, and then copied from the first stage of the shift register back into the core it came from. The timing counter then advances to the next bit address and the cycle repeats. The "write" mode is the same, except that data is recirculated from the end of the shift register back to the beginning instead of reading in the values from the core memory. Assignments in the 32-bit command word are as follows:

- 24 bits: 8 3-bit words for gain & offset for high and low frequency for RF and DC amplitudes for the rods.
- 2 bits: Pulse Amp Discriminator Level
- 3 bits: Multiplier High Voltage Supply Amplitude
- 3 bits: Spare

The Mass Control Processor is a digital calculator performing a function that has been done by analog circuits and multiplying A/D converters in the past. The task is to perform the calculations

$$M' = (M \times a) + b$$

$$M'' = (M \times c) + d$$

to produce control values for the RF amplitude and the DC amplitudes for the rods.

Scaling of the various values is:

$M\ (LSB) = 1 \times 2^{-8} \times M(\text{full scale}) \pm 1 \times 2^{-11} \times M(\text{f.s.}),$

$\text{then} \pm a(LSB) \times M(LSB) = \pm 1 \times 2^{-11} \times M(\text{f.s.})$

$\text{and} \pm b(LSB) = \pm 1 \times 2^{-11} \times M(\text{f.s.})$

From this it can be seen that a 12-bit result, driving a 12-bit D/A converter should be equal to the task. Double-precision calculation will be performed on an 8-bit microprocessor. Limiting the program ROM to 128 bytes (which, supposedly, is sufficient) allows the data sources of M, a, b, c, d, and the sinks of M' and M" to occupy address-space with very simple decoding of the address bus. Results are deposited in intermediate registers upon completion of the calculations and transferred to the D/A's at the start of the next integration time-out period. This complication on the timing may prove unnecessary upon further study.

Analog outputs for Ion Energy, Discriminator Level, and High Voltage Amplitude are generated by D/A converters consisting of discrete resistors selected for the output value required and analog switches to connect the desired resistor to a buffer amplifier.

The Pulse Counter consists of an amplitude discriminator, a counting chain, and decision and multiplexing logic to perform a floating-point conversion for data compression. The high speed portion of the counter, built out of Shottkey and Low-Power Shottkey, as shown, has been operated to 125 MHz successfully. The comparator function is an unknown, as to speed. The device shown, the fastest TTL-output comperator that could be discovered (on paper) is probably twice as slow as the first Shottkey flip-flop stage which follows it. J-K flip-flops are used to allow control of the first stage to start

and stop counting. For lack of specifications, the timing relationships of DE data enables and data clock were used as the basis for count/shift control. A 16-bit priority encoder is implemented to find the value of the largest filled bit location. This value is loaded into a register and held for the duration of the data output enable to control the multiplexer which selects the appropriate point in the data shift register to collect the fraction value. The priority encoder output is also loaded into a shift register stage as part of the output data. A test point is provided, hardwired to the most-significant-bit stage of the data shift register. Looking at that point while providing a 24-bit data enable will shift out the uncompressed linear data.

The Analog Multiplexer and A/D system consists of the multiplexer, an additional analog switch, a buffer amplifier, the A/D converter, and a parallel-in/serial-out shift register. The 16-input multiplexer is driven by the low-order four bits of the Mass Select code. Further selection of the multiplexer output or the output of the Log Electrometer Amplifier is controlled by a bit from the Program ROM. Another bit from the ROM enables operation of the A/D converter, while a third dedicates the output data stream to either the most recent digital value or the A/D output value. This configuration allows gathering an analog value during one integration and holding the result for later transmission during a "dead spot" in the digital data stream. In this fashion simultaneous samples may be taken from the two data systems for gain checks and the like.

B. Elero

THE UNIVERSITY OF MICHIGAN

ANN ARBOR

SPACE PHYSICS RESEARCH LABORATORY

August 21, 1978

M E M O R A N D U M

MEMO TO: Galileo Distribution

FROM: W. H. Pinkus WHP 8/21/78

SUBJECT: Mission Timeline

Attached is an abstract of the Mission Timeline given in JP-501, a similarly coarse NMS Timeline, a plot of Entry Probe Altitude (in pressure) vs. Time, and an outline of thoughts on the modes of operation the NMS should be capable of supplying. All comments on the last will be appreciated (maybe).

WHP:slj

Galileo Mission Timeline

(abstracted from JP-501)

Launch: 10 day window to leave Earth orbit begins 6 January, 1982.

Transit: (≈ 1200 days) Opportunities will occur for periodic health checks of the instruments, timing TBD. Final health check & command opportunity will be shortly before separation from the Orbiter @ E-100 days.

Pre-Entry: When Coast Timer times out, data system and Sequence Programmer are turned on. This phase ends at entry into the atmosphere. Possibility of doing calibration checks (≤ 2 minute duration) near end of period (≈ 2 R_J; ≈ 90 minutes before beginning of Science Mission). NMS pump activated (turned on?) at this time.

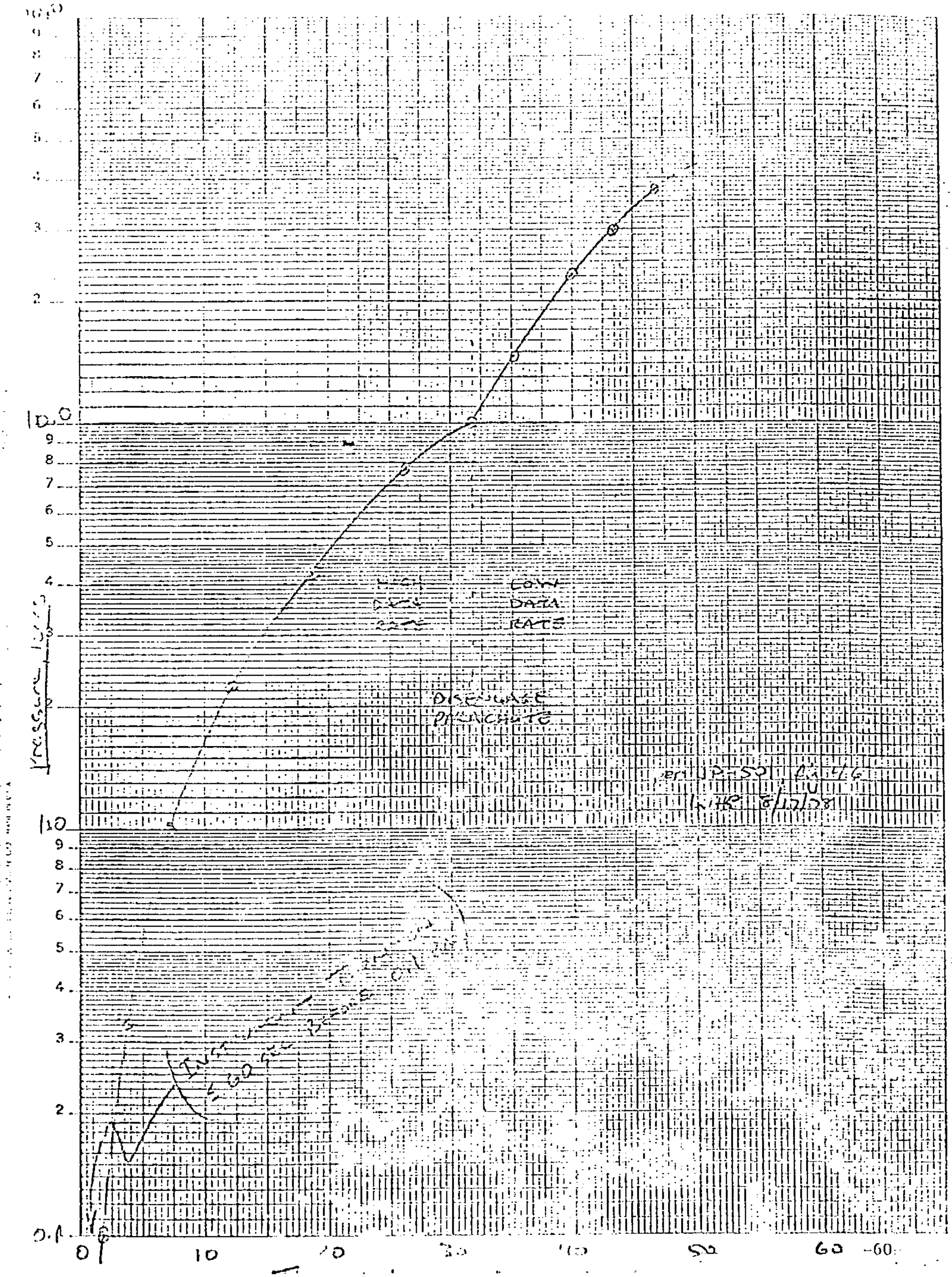
Entry: Period of high G forces, orientational instability. Acceleration switch will signal fall-off of G forces, start Descent Phase program. Period lasts ≈ 2 minutes.

Descent (I): Beginning @ ≈ 0.1 Bar, through ≈ 10 Bar - main science period. All instruments on. Lasts ≈ 30 minutes.

Descent (II): Lasts additional 15 minutes. Reduced data rate. Begins at jetison of the parachute @ ≈ 10 Bar.

Galileo NMS Descent Timeline

Time	Altitude/Pressure	S/C Cmds	Inst. Function
E - 100 days	--	inst on/off	final checkout
E - 2 hours	$2R_J$	(optional checkout)	
E - 0 minutes	450 km	(atmosphere entry)	
E + 1 minute		Inst on	abbrev. checkout
E + 1.94 minutes	0.1 Bar	Science Enable (high data rate)	Science Sequence
E + 31.94 minutes	10 Bar	(release parachute) (low data rate)	Science Sequence
E + 45 minutes	35 Bar	(end of mission) [loss of signal by orbiter]	



LOW
DATA
RATE
0
10
20
40
60

Galileo NMS: Types of operation to be provided:

I. Ground Testing with GSE

A. Operating Modes

1. Standard Flight Sequences

a. Provide "fast forward" mode to get to any point in the sequence rapidly

b. Provide "hold" mode to repeat any program step as long as desired

c. Provide "single step" mode for slow stepping through the program

2. Override mode

a. GSE provides microprogram code to instrument on an integration-by-integration basis, superceding the output of the internal ROM program.

B. Data Display

1. Provide GSE-only data output ports to make full internal instrument status visible for every integration

a. Program timer code

b. Microprogram code

c. Command status

2. Normal TM data stream

a. Must continue & not loose step in the face of Program Sequence start/stop.

II. Testing via TM system with instrument in the Spacecraft

A. Operating Mode is built-in checkout sequence, which must be repetitive (rather than open-ended like Science Sequence).

1. Need sufficient operating time to provide full display of all instrument parameters.

2. Need to examine at least six mass peaks to verify tuning of all three frequencies. (i.e., two peaks in each frequency).

3. Provide some means of "dry run" checking all valve operations(?)

B. Data Display is via TM system

1. Might want to "lock out" Analog Science Data from Housekeeping channel every other cycle to ensure getting the Housekeeping info, conversely allow 100% takeover in cycles when not "locked out".

III. Abbreviated Checkout before Entry (@2R_J)

A. See no benefit to doing this

1. Data is stored until Descent period

2. Is before the Entry shock, which will probably be the major event affecting instrument operation between the E - 100 day check and the actual Science Mission.

IV. Abbreviated Checkout after Entry (@ 0.1 Bar)

A. Operating Mode

1. Simple mass scan before opening instrument to atmosphere

2. Time available is severely limited

B. Data is normal TM data, no special requirements on housekeeping data since this is contiguous with the Science Mission data

V. Science Mission

A. Operating Mode

1. 45 minute programmed sequence stored in ROM; each 0.5 second integration individually fully defined by a "microprogram code" word of its own

2. Follows immediately upon end of "Abbreviated checkout after Entry"; enabled by signal from Probe Sequence Timer

3. Signal for enabling Science Mission Mode will be latched, reversal accomplished by cycling instrument power

   a. Enables Science Mission sequence

   b. Arms Inlet System

5. Data Display by normal TM stream

   1. Data output is 16 bits per half-second integration

      a. 1 bit to flag Digital or Analog telemetry of Science Data in the Science Data field

      b. 13 bits normally contain digital readout of Science Data

      c. 2 bits normally contain housekeeping information, formatted as 16, 8-bit words stuffed in two bits at a time

      d. In "overlap" region where both Digital and Analog Science Data are valid, the Analog will be inserted in place of the Housekeeping Data to a maximum of 50% of the Housekeeping data rate

      e. In the "High Output" region where the Digital Science Data has little validity, the Analog will be inserted in its place, leaving the Housekeeping data alone

      f. The Housekeeping data will consist of 14 analog parameter measurements (8 bit resolution) and an 8-bit representation of Inlet System status, repeating every 32 seconds. The 16th word in this format will be subcomutated to provide Command Status and Instrument time code information, repeating every 256 seconds (4.27 minutes).

D. Ekero

THE UNIVERSITY OF MICHIGAN
ANN ARBOR

SPACE PHYSICS RESEARCH LABORATORY

August 28, 1978

M E M O R A N D U M

MEMO TO: Galileo Distribution

FROM: Bill Potter

SUBJECT: Establishing Synchronization Between the ROM Sequencer and the T/M Frame Structure

Synchronization between the NMS circuitry which sequences the program ROM and the S/C T/M frame structure will be established if the NMS Power On command occurs at the proper time with respect to the T/M frame structure. The ROM sequencer will begin to count on the first NMS Data Envelope signal received after the NMS completes its power-on-reset sequence. Ideally, the ROM sequence should start with the first Data Envelope of a T/M major frame, but we can do this only if a T/M major frame is timed to begin to begin at a time very close to the nominal turn-on time of the NMS instrument at the 100 mbar level. We cannot afford to delay the turn-on to wait for the T/M. The duration of a major frame is 4.27 minutes, and if the NMS turn-on were delayed by an appreciable fraction of this time, we would lose vital data.

If we cannot turn on at the beginning of a major frame, the next best thing would be to turn on at the beginning of a T/M minor frame, preferably frame 9, 17, 25, 33, 41, 49, or 57 of the major frame (assuming the minor frames are numbered 1 thru 64). Any one of these timings will establish that an NMS block (defined below) will begin at the start of a T/M major frame.

Power-On Timing

Following the NMS Power-On command, the instrument requires a period of approximately 0.1 sec, for the Power-On reset function before it can respond to any external signals. Thus to establish a synchronization between the NMS ROM sequencer and the T/M frame structure where the ROM sequence beings at the start of a frame requires that the NMS Power-On command occur sometime after the last NMS Data Envelope of one frame, and at least 0.1 sec before the first NMS Data Envelope of the next frame. The ROM sequencer will start counting with the first NMS Data Envelope following the completion of the Power-On reset function.

Re-Syncing the ROM Sequencer

If the ROM Sequencer is started at a known time with respect to the T/M frame structure, at the start of the descent phase of the mission, they should stay in synchronization for the remainder of the mission, provided

both count correctly. Provision could be made periodically resyncing the ROM sequencer in case they do get out of step. However, inclusion of resyncing circuitry might reduce, rather than increase the overall probability of a successful mission. The decision to include resyncing provisions should be made only after considering all of the reliability factors.

If a sync code is included in the NMS data, then it will be possible to correctly interpret this data, even if synchronization with the T/M timing is lost.

Organizing the NMS Data into "Blocks"

It would seem useful to organize the NMS data into blocks of 64 data word of 16 bits each. Such a block seems to be about the right size for a normal mass spectrum scan and some overhead data. If the science requires that during part of the mission the number of masses sampled by significantly larger or smaller than about 60, we can easily devise systematic means for packing these longer or shorter scans into 64 word blocks. The advantage of such a block structure lie entirely in the ease it lends to the process of planning the ROM sequence for the mission, and in the ease of interpreting the T/M data. The use of the ROM as a programmer for the instrument allows a sequence of samples which has no periodic structure whatsoever.

A block of 64 sample words requires 32 seconds of real time, or 128 T/M bytes spread over 8 minor frames at 16 bits per minor frame. There are 5 blocks in a major frame. For convenience in interpreting the data, each major frame should being with a new block.

A block will consist of a number of ion count samples and some overhead data. The overhead data may include such items as:

1. Readout of the ROM sequence counter at the beginning of the block.

2. Readout of the "fine tuning" commands currently in effect.

3. Readout of the valve sequence state, and also possibly some feedback data to verify valve operation.

4. Tag bits to identify which data samples were derived from ion counts, and which were from an analog readout to accomodate extremely high count rates.

5. Any special codes that we may include in our data stream to allow us to recognize the start of scans or blocks independently of the T/M frame structure.

6. Housekeeping data (temperature, critical voltages, etc.)

Normally the inlet valves will change state at the start of a block. If a few seconds are required after a valve change for the old mixture to purge from the plumbing, those time slots could be used for overhead data without losing any useful science.

WHP:abj

B. Elero

THE UNIVERSITY OF MICHIGAN
ANN ARBOR

SPACE PHYSICS RESEARCH LABORATORY

August 28, 1978

M E M O R A D U M

MEMO TO: Galileo Distribution

FROM: W. H. Potter

SUBJECT: Interface Timing: ROM Sequencer and T/M Data

Purpose:

The purpose of this memo is to gather together a tentative description of the timing aspects of the NMS Instrument/Galileo Spacecraft T/M interface, based upon what information is now available, and to suggest some alternative choices for some of the parameters that are still undefined.

Many Galileo parameters are presently defined only by the statement "like Pioneer Venus". Accordingly, I have taken all of the word and bit timing (Word Envelope, read clock, etc.) and the T/M frame structure from Pioneer Venus documents.

Interface Characteristics that seem to be Tentatively fixed:

The spacecraft T/M format is organized into bytes of 8 bits each, which are grouped into minor frames of 64 bytes each, which in turn are grouped into major frames of 64 minor frames each. (I shall use the word "byte" to describe the 8 bit unit to avoid confusion with the 16 bit units produced by the NMS instrument. The spacecraft literature refers to these 8 bit units as "words.") Table I gives the relationship between these units, and their time duration when the T/M is operating at the nominal rate of 128 bits/sec.

The transfer of data from instrument to T/M is reported to be "like Pioneer/Venus." The waveforms and timing for a single byte transfer in P/V are shown in Figure I, where the Read Envelope and Read Clock are generated by the S/C. and the Serial Data is generated by the Instrument.

Table [illegible] -- Relationship Among Data Units; T/M Format

	Bits	Bytes	NMS Sample	Minor Frame	Major Frame	Time (sec)
Major Frame	32,768	4,096	2,048	64	1	256
Minor Frame	512	64	32	1		4
NMS Sample	16	2	1			1/8
T/M Byte	8	1				1/16
Bit	1					1/128

NMS Output Characteristics:

The NMS Instrument produces data in the form of 16 bit/sample words, of which 13 bits constitute the floating point count from the mass spectrometer, and the remaining three bits are available for multiplexing housekeeping information and such additional timing and synchronization as seems required. A sample word, therefore requires two T/M bytes. A sample word is generated every 0.5 sec, so the NMS generates 8 samples, or 16 bytes for every T/M minor frame, equivalent to 1/4 of the T/M capability of the S/C.

The NMS Instrument is programmed by a read only memory (ROM) capable of storing a separate command for each data sample during the entire descent phase of the Probe. Each command specifies the atomic mass number to be measured, among other things, so that there are essentially no hardware restrictions on the sequence of sampling, and the sequence can be entirely independent of the frame structure of the T/M system. There need not even be any repetitive sequences in the program. However, it seems likely that, as the program is defined, it will fall naturally into "scans", in which a set of masses is sampled more or less sequentially, even though the set of masses sampled, and probably even the number of masses sampled, will vary from scan to scan. We would probably lose little flexibility if we organize the ROM program into standard blocks of 64 samples each, provided we recognize that during some parts of the mission we may program two actual scans per block, or three actual scans for two blocks, or other combinations. A block of 64 samples would correspond to two minor T/M frames. Structuring the program into such blocks would greatly simplify the data anaylsis. In particular, structuring calibration and checkout programs into such blocks would greatly simplify the GSE.

The Problem of Identifying Data in the T/M Stream:

Obviously we must be able to identify each data sample in the T/M data stream with the ROM program step which produced it. We may do this either by locking the ROM program sequencer to the T/M frame counter or some other time signal generated in the S/C, or by letting our ROM

sequencer run independently and putting timing information into our T/M data stream. There are advantages in doing both.

Several alternative methods for locking the ROM sequencer to the S/C timing are available:

1. At power-on, the ROM sequencer comes up locked in the zero state, and stays there until receipt of an unlock signal that occurs at a known point in the S/C timer sequence.

2. At power-on, the ROM sequencer starts at the zero state and steps with each data sample. Periodic synchronizing pulses from the S/C keep the ROM sequencer in step with the T/M frame structure. For example, a synchronizing pulse every minor frame could be used to reset the five low-order bits of the ROM sequencer, keeping it in sync with the T/M frames. A pulse every major frame could be used to reset the low order eleven bits of the ROM sequencer.

3. The Science Sequence Enable signal will presumably occur at a known time with respect to the T/M sequence, and could be used to preset the ROM sequencer to a specific position, as well as to enable it to precede from the calibration sequence to the science data-gathering sequence.

4. Transmit to the NMS a portion of the count in the S/C which identifies the byte positions within the minor frame, and use these as the low-order bits of the ROM sequence code. Discard the low order bit.

Timing Information in the T/M Data Stream:

There are several alternative methods whereby timing and identification information may be included in our T/M data, utilizing the extra three bits of each sample word, and sharing them with housekeeping data:

1. Use the hi-order bit of each sample word for timing, and the other two bits for multiplexed housekeeping data. Put a "1" in the hi-order bit for the first sample of each scan, like IECM. There is no identification of scans, except by counting scans from some landmark. There are 128 bits available for housekeeping data for each scan.

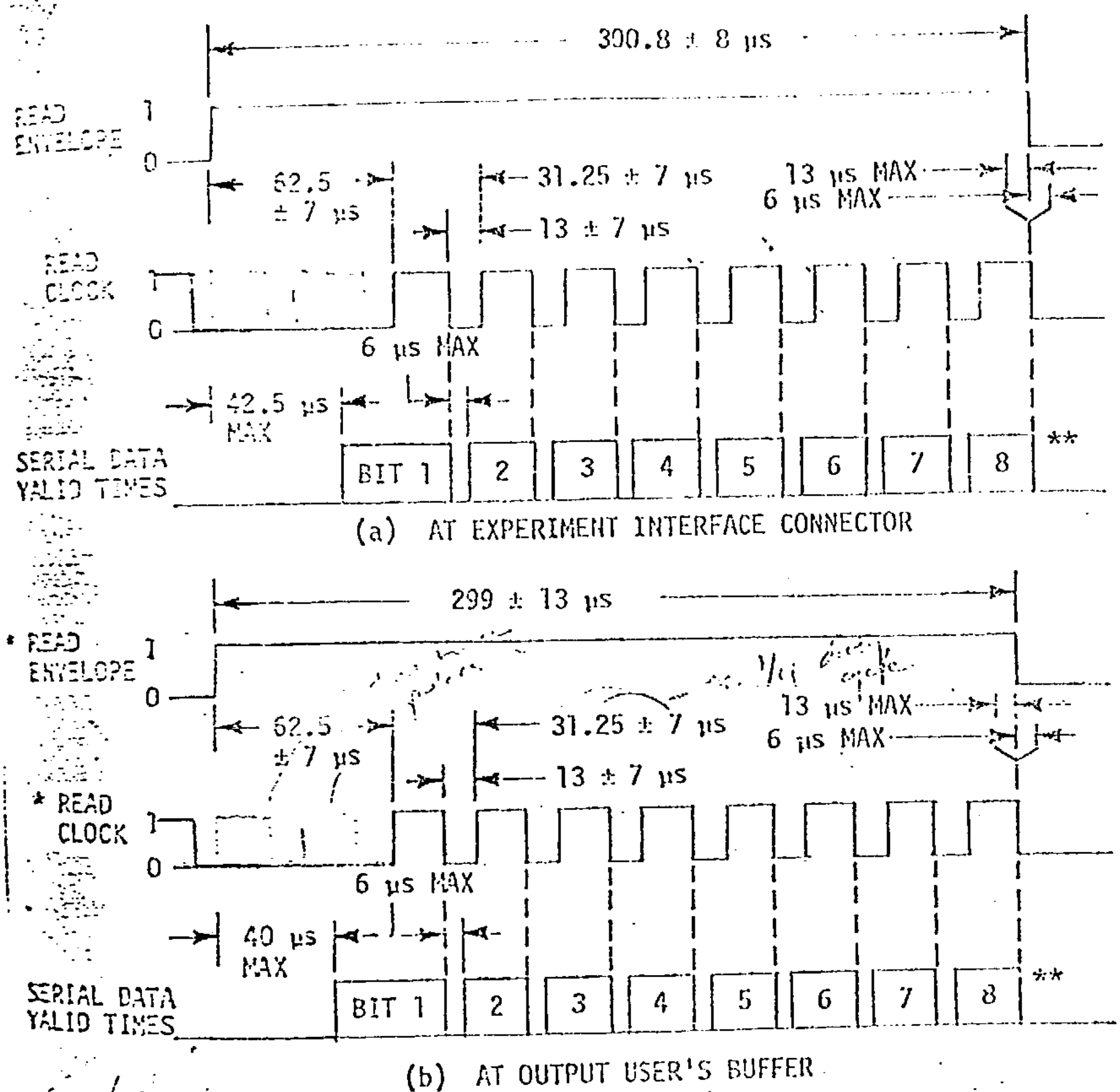
2. Use the hi-bit of the sample word for timing and the other two housekeeping as before, except that instead of a single "1" in the hi-bit for each scan, we put a conventional snyc code, followed by the bits of the ROM sequence counter. These codes would appear in serial form, one bit in each sample word; they would give us complete information as to what part of the ROM program produced the data. There would also be enough bits left over to read out the actual ROM command for one or two samples of the scan, if desired. Also, we could read out the

inlet sequencer state.

There are 128 bits available for housekeeping data, as with alternative 1.

3. Use all three of the available bits from some words for timing information, and all three bits of the remaining words for housekeeping. If, for example, we allocate 21 bits for the sync code and 15 bits for the ROM sequence count, we have 156 bits left for housekeeping data, more than with the other options. A 21 bit sync code is enough bits, that assuming that the rest of the data is random and that we ignore all frame information from the S/C, the probability of a false coincidence any time during the 6144 samples (12,288 bytes) during the descent phase is only 1/171. (Designing an efficient octal sync code seems to be easier than designing an efficient binary sync code.) Thus, we can reliably interpret our data, given only a string of bytes from the NMS Instruemnt and the knowledge of the sampling sequence in the ROM.

If the NMS instrument includes any provisio. to jump to a different part of the program if an unexpectedly high pressure is encountered, it becomes even more desirable to include enough data in our data stream to determine unambiguously the point in the ROM program which produced each data sample.



$\frac{1}{31.25\,\mu s}$ = 32.000 kHz

* READ ENVELOPE AND READ CLOCK SIGNALS AS SHOWN REPRESENT WAVEFORMS AT OUTPUT OF USER'S INPUT BUFFER PLUS ONE TTL INVERTER.

** DATA MUST BE VALID UNTIL EITHER THE CLOCK OR THE ENVELOPE STARTS TO FALL TO ZERO.

Figure I —— Galileo Probe T/M Byte Timing

Assumed same as Pioneer Venus. Taken from P/V drawing.

12 September, 1978
GRC

GALILEO NMS
DESIGN NOTE

The attached table illustrates a workable instrument time - line. The first 288 integration periods (144 seconds) are shown. During the first 32 of these integration periods an eight point tune check of 4 masses is made and the 64 bits of housekeeping data are taken over for a one time command state readback. The tune checks can be repeated at any time since this is under control of the instrument ROM. Each row in the table of 8 integration periods corresponds to a spacecraft minor frame during which a total of 16 bits are available for housekeeping data. Eight of these bits are assigned to a reading of Multiplier current, I_m, and the other eight to other monitors. Any 1 of the 8 masses during a spacecraft minor frame can be selected for an I_m reading, the value of which will be telemetered during the next minor frame. A 32 word multiplexer has been selected and is shown for purposes of illustration with A1 being sampled at 4 equally spaced locations, A2 at 2 and the remainder at 1 location. The last 4 words allow for 32 bits of digital housekeeping. A total of 256 integration periods, 128 seconds, is required to retrieve a full set of multiplexed values. This adds with the 16 second turn-on command state readback to give 144 seconds, the time required from turn-on to get a full set of housekeeping data.

Following the 16 second initial sequence, a 64 mass background scan is shown followed by breakoff. The number of masses in the background scan is arbitrary and could be reduced if 48 seconds seems too long to spend before

getting at the Jovian atmosphere. Following the background scan the mass program deemed appropriate for the early analysis of the Jovian atmosphere is called.

During ground and cruise tests the instrument operates in the same way except that breakoff is inhibited. At normal speed 144 seconds are required for a full check-out. Each of the selectable ionization energies should be called at least once during this period so that this instrument function would be exercised. The digital words at the end of the 144 second interval includes inlet-sequencer state which would have advanced at least one step during the interval, partially checking this function.

The desired scenario at entry is to turn the instrument on at some time prior to decelleration so that it is warmed-up when measurements are started. A signal is thus required at the moment when telemetry begins which would be used to reset the 13 bit counter driving the ROM to its zero state. Ideally this would occur 48 seconds above 0.1 bar so that breakoff would initiate measurements at the specified pressure level. This counter would also be reset at instrument turn-on and it is probably desirable to have this reset commandable as perhaps intrinsically it would be on the same line that provides the post entry signal.

Most of the details the turn-on sequence remain flexible. The "waste" of 16 seconds for tune checks at Jupiter seems to be the only possible objection to this scheme. Its virtues are hardware simplicity and the attribute that every turn-on is identical to the entry sequence.

The evaluation of multiplier characteristics during cruise presents an operational complexity. The instrument is provided with eight commandable high voltages and four commandable discriminator levels. The ideal multiplier evaluation program would be one in which an appropriate mass would be selected and a 32 step (8 high voltages X 4 discriminator levels) sequence would be executed with simultaneous measurement of I_{GRID}, Count, and Multiplier and High Voltage Monitor. This is possible on the ground but rather impractical during cruise. Alternatively, for each combination of high voltage and discriminator level needed (this would probably be much fewer than 32; e.g., 4 discriminator levels to select the correct one and 6 high voltage values following, for a total of 10 combinations) the instrument would be allowed to proceed from step 0 through enough integration periods to get the necessary information. By programming the ROM with this need in mind 48 integration periods should suffice (16 past the 32 integration period tune check). The procedure would thus be to command the appropriate combination of high voltage and discriminator level, send the reset command, take 24 seconds of data, send the second combination, reset, take 24 seconds of data etc. For 10 combinations this would require 240 seconds plus command time (guess 60 seconds) for a total of 300 seconds. Since this detailed check is required only infrequently this amount of time is probably acceptable. This technique puts no additional hardware requirements on the instrument and only requires some forethought in programming integration periods 33 through 48.

Galileo NMS Turn-on Timeline (Illustrative)

12 Sept 1985 GRC

1	2	3	4	5	6	7	8	TIME SEC	MAIN DATA		HSKG
1	2	3	4	5	6	7	8	4	POINT	1	64 BIT
9	10	11	12	13	14	15	16	8	TUNE	2	CMD
17	18	19	20	21	22	23	24	12	CHECK	3	STATE
25	26	27	28	29	30	31	32	16	4 MASSES	4	
33	34	35	36	37	38	39	40	20			IM A1
41							48	24			A2
49							56	28			A3
57							64	32	64 MASS		A4
65							72	36	BKG		A5
73							80	40			A6
81							88	44			A7
89							96	48	Breakoff		A8
97							104				A1
105							112				A9
113							120				A10
121							128				A11
129							136				A12
137							144				A13
145							152				A14
153							160				A15
161							168				A1
169							176				A2
177							184				A16
185							192		SELECTED		A17
193							200		MASSES		A18
201							208				A19
209							216				A20
217							224				A21
225							232				A1
233							240				A22
241							248				A23
249							256				A24
257							264				D1
265							272				D2
273							280				D3
281						287	288	144			D4
											A1
											A2
											A3
											etc.

B. ELERO

THE UNIVERSITY OF MICHIGAN
ANN ARBOR

SPACE PHYSICS RESEARCH LABORATORY

September 13, 1978

MEMO TO: Galileo Distribution

FROM: W. H. Potter

SUBJECT: Fine Tuning Corrections

It is proposed that the NMS instrument include provision to "fine tune" the mass spectrometer by ground command. This fine tuning would take the form of slight adjustments to the gain and offset of the V_{ac} and V_{dc} control voltages, with separate adjustments for each of the three frequency ranges. Thus there are a total of six gain/offset pairs. In addition, it is proposed to adjust the high voltage to the electron multiplier and the threshhold of the pulse amplifier.

It is possible that the instrument may prove sufficiently stable that some adjustments on some frequency ranges can either be dispensed with or combined with other adjustments. For purposes of this memo, however, I assume the worst, and provide full adjustment capability.

Assume that the mass ranges covered by each of the oscillator frequencies are:

Lo range	Mass 1 to 6
Mid range	Mass 6 to 52
Hi range	Mass 52 to 255

Let us represent the correction operation by:

$y = mx + b$, where:

x is the nominal atomic mass number read from the ROM as part of the program command, and is an 8-bit binary number.

y is the corrected "mass," represented by a voltage which, after appropriate amplification, will control V_{ac} or V_{dc} to the quadrupole.

b is the offset correction: $-1<b<+1$.

m is the gain correction: $m \cong 1$.

since m has a value near 1, we may best use the transform

$m = 1 + m'$,

where $m' << 1$. Fewer bits are required for an adequate representation of m' than m. We would then transmit m' as a part of the command, and compute $m = 1 + m'$ on board.

Quantizing m and b:

Since m and b are to be transmitted as digital quantities, and it is important to keep the number of bits to a minimum, resolution becomes the driving factor in choosing a method of implementation. Let us assume that the required resolution is 1/8 of an atomic mass unit. This means that m' and b must be so scaled that a change in the lo-order bit of either does not produce a change in V_{ac} or V_{dc} that exceeds 1/8 AMU at any mass. It is obvious, then that the resolution in b must be equivalent to 1/8 AMU. The effect of an increment in m, however, is not so obvious, and must be computed.

We may restate the resolution requirement more rigorously. Since y is a linear function of x, we may adjust m and b so as to fit any two given points (x_1, y_1) and (x_2, y_2). The fact that m and b are quantized, however, prevents us from fitting exactly some pairs of points. For no pair of given points should the y value generated by the quantized m and b differ from the desired value by more than ± 1/16 AMU.

Range of m and b:

The range of values which m and b take is limited by the number of bits transmitted, and by the resolution. The range limitations will confine the function $y = mx + b$ to lines which fall within the cross-hatched region of Figure 1. Note that this region is narrowest at $x = 0$, and widest for the highest value of x. This property will allow the maximum correction for drifts at the highest atomic masses, which seems to be the place where corrections are most likely to be needed. If, however, the maximum drift should appear at the low mass region, the function may be altered to:

$$y = m(x - x') + b + y',$$

where x' and y' are constants. The zone of possible corrections is then narrowest in the vicinity of (x', y').

For this memo, I will continue to use $y - mx + b$.

Resolution in m:

If Δy is the acceptable resolution element in y, and Δm the resolution element in m which would produce Δy, then:

$$\Delta y = (m + \Delta m)\, x_{max} + b - (m x_{max} + b)$$

$$= \Delta m\, x_{max}$$

$$\Delta m = \frac{\Delta y}{x_{max}},$$

where x_{max} is the x value of the upper limit of the range for one oscillator frequency. Using Δy = 1/8 AMU, we get the figures given in Table I for the range of the corrections available to m for three bits of m'.

The range of gain change available in the hi mass range looks very small. Actually, this reflects the fact that the effective gain in the hi range must be very accurately controlled if the "bandwidth" of the quadrupole is sufficiently narrow that one mass unit is resolved at mass 255.

To my knowledge, we have no clearly stated requirement to resolve one mass unit at 255. If no such requirement exists, we can achieve a greater range of gain adjustment is the hi mass range with three bits of m'.

TABLE I:

	Lo Range	Mid Range	Hi Range
x_{max}	6	52	255
Ideal Δm	1/48	1/416	1/2040
Nearest binary Δm	1/32 2^{-5}	1/512 2^{-9}	1/2048 2^{-11}
Max. correction with three bits	$\pm 1/8$ $\pm 2^{-3}$	1/128 2^{-7}	1/512 2^{-9}

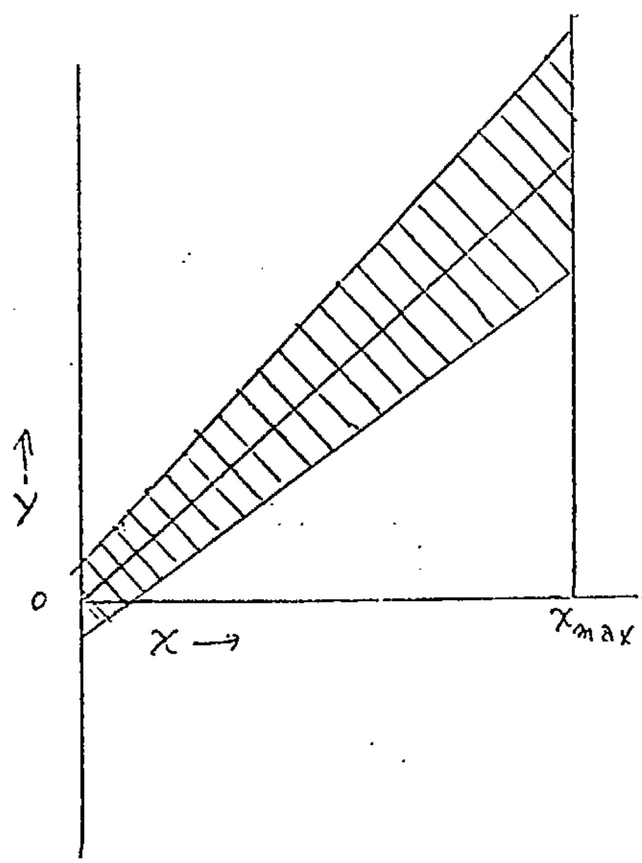


Figure 1
Available Range of Adjustment

THE UNIVERSITY OF MICHIGAN
ANN ARBOR

SPACE PHYSICS RESEARCH LABORATORY

September 14, 1978

M E M O R A N D U M

MAIL TO: Galileo NMS File

FROM: G. R. Carignan

SUBJECT: Electronics Design

Some of the discussions at the Galileo NMS engineering meeting resulted in decisions which were needed to proceed with design. Three areas in which this is true are discussed in the attached brief design notes which are being circulated for concurrence. These are the detection system, the instrument formatting and the data handling and its relationship to data processing.

Additional conceptual questions were raised which are being studied. These are identified below with names associated with specific tasks.

(1) Electrode Bias Supply

A. Conceptual Design - John Maurer

(2) Inlet System

A. Requirements - Jim Cooley
B. Interface Issues - Bernie Elero
C. Conceptual Design -- Jack Caldwell

(3) Ion Source Status & Filament Select

A. Criteria - Hasso Niemann

(4) V_{AC} & V_{DC} Adjust Concept

A. Design - Walt Pinkus

Galileo EMS File
September 14, 1978
Page 2

These tasks are in addition to the continued design effort on those circuits where a consensus concept exists.

These conceptual issued should be addressed immediately and resulting information circulated to enable presentations of implementation schemes at the October engineering meeting.

[illegible]

Attachment

12 September, 1978
GRC

GALILEO NMS
DESIGN NOTE

Housekeeping and Related Issues

The attached table illustrates a workable instrument time - line. The first 288 integration periods (144 seconds) are shown. During the first 32 of these integration periods an eight point tune check of 4 masses is made and the 64 bits of housekeeping data are taken over for a one time command state readback. The tune checks can be repeated at any time since this is under control of the instrument ROM. Each row in the table of 8 integration periods corresponds to a spacecraft minor frame during which a total of 16 bits are available for housekeeping data. Eight of these bits are assigned to a reading of Multiplier current, I_m, and the other eight to other monitors. Any 1 of the 8 masses during a spacecraft minor frame can be selected for an I_m reading, the value of which will be telemetered during the next minor frame. A 32 word multiplexer has been selected and is shown for purposes of illustration with A1 being sampled at 4 equally spaced locations, A2 at 2 and the remainder at 1 location. The last 4 words allow for 32 bits of digital housekeeping. A total of 256 integration periods, 128 seconds, is required to retrieve a full set of multiplexed values. This adds with the 16 second turn-on command state readback to give 144 seconds, the time required from turn-on to get a full set of housekeeping data.

Following the 16 second initial sequence, a 64 mass background scan is shown followed by breakoff. The number of masses in the background scan is arbitrary and could be reduced if 48 seconds seems too long to spend before

getting at the Jovian atmosphere. Following the background scan the mass program deemed appropriate for the early analysis of the Jovian atmosphere is called.

During ground and cruise tests the instrument operates in the same way except that breakoff is inhibited. At normal speed 144 seconds are required for a full check-out. Each of the selectable ionization energies should be called at least once during this period so that this instrument function would be exercised. The digital words at the end of the 144 second interval includes inlet-sequencer state which would have advanced at least one step during the interval, partially checking this function.

The desired scenario at entry is to turn the instrument on at some time prior to deceleration so that it is warmed-up when measurements are started. A signal is thus required at the moment when telemetry begins which would be used to reset the 13 bit counter driving the ROM to its zero state. Ideally this would occur 48 seconds above 0.1 bar so that breakoff would initiate measurements at the specified pressure level. This counter would also be reset at instrument turn-on and it is probably desirable to have this reset commandable as perhaps intrinsically it would be on the same line that provides the post entry signal.

Most of the details the turn-on sequence remain flexible. The "waste" of 16 seconds for tune checks at Jupiter seems to be the only possible objection to this scheme. Its virtues are hardware simplicity and the attribute that every turn-on is identical to the entry sequence.

The evaluation of multiplier characteristics during cruise presents an operational complexity. The instrument is provided with eight commandable high voltages and four commandable discriminator levels. The ideal multiplier evaluation program would be one in which an appropriate mass would be selected and a 32 step (8 high voltages X 4 discriminator levels) sequence would be executed with simultaneous measurement of I_{GRID}, Count, and I Multiplier and High Voltage Monitor. This is possible on the ground but rather impractical during cruise. Alternatively, for each combination of high voltage and discriminator level needed (this would probably be much fewer than 32; e.g., 4 discriminator levels to select the correct one and 6 high voltage values following, for a total of 10 combinations) the instrument would be allowed to proceed from step 0 through enough integration periods to get the necessary information. By programming the ROM with this need in mind 48 integration periods should suffice (16 past the 32 integration period tune check). The procedure would thus be to command the appropriate combination of high voltage and discriminator level, send the reset command, take 24 seconds of data, send the second combination, reset, take 24 seconds of data etc. For 10 combinations this would require 240 seconds plus command time (guess 60 seconds) for a total of 300 seconds. Since this detailed check is required only infrequently this amount of time is probably acceptable. This technique puts no additional hardware requirements on the instrument and only requires some forethought in programming integration periods 33 through 48.

Galileo NMS Turn-on Timeline (Illustrated)

(assumes NDS GPC)

1	2	3	4	5	6	7	8	TIME	MAIN DATA	HSKG
1	2	3	4	5	6	7	8	4	2 POINT 1	64 bit
9	10	11	12	13	14	15	16	8	TUNE 2	CMD
17	18	19	20	21	22	23	24	12	CHECK 3	STATE
25	26	27	28	29	30	31	32	16	4 MASSES 4	
33	34	35	36	37	38	39	40	20		IM A1
41							48	24		A2
49							56	28		A3
57							64	32	64 Mass	A4
65							72	36	BKG	A5
73							80	40		A6
81							88	44		A7
89							96	48	Break off	A8
97							104			A9
105							112			A9
113							120			A10
121							128			A11
129							136			A12
137							144			A13
145							152			A14
153							160			A15
161							168			A15
169							176			A16
177							184			A16
185							192		SELECTED	A17
193							200		MASSES	A18
201							208			A19
209							216			A20
217							224			A21
225							232			A21
233							240			A22
241							248			A23
249							256			A24
257							264			D1
265							272			D2
273							280			D3
281						287	288	144		D4
										A1
										A2
										A3
										etc.

13 September, 1978
GRC

DESIGN NOTE

GALILEO NMS DETECTOR SUBSYSTEM

At a Galileo NMS meeting on 30 August, 1978, decisions were made with regard to the detection subsystem which permit completion of the detailed design. It is the purpose of this note to document the consensus design.

The sensor will include two detectors, a grid near the exit of the rods which will intercept 20% of the ion flux and a continuous dynode multiplier which will collect the other 80% and convert each ion into an electron pulse of average value of 2 to 3 x 10^6 electrons.

The electronic system will provide three separate detection channels:

(1) a linear electrometer measuring grid current;

(2) a linear electrometer measuring multiplier current; and

(3) a pulse counter measuring ion arrival rate.

The output of either the counter or the grid electrometer will be fed to the telemetry with the decision on which based on the value of the multiplier current. The multiplier current will be telemetered once each eight integration periods utilizing the housekeeping bits.

The following specifications apply to the detection channels.

(1) Grid Electrometer

Linear

10 volts full scale corresponding to 10^{-10} amps
12 bit digitization of output
Accuracy 0.05% full scale (5 mv)
Time Constant <.05 secs.

(2) Multiplier Electrometer

Linear

10 volts full scale corresponding to 3 x 10^{-5} amps
8 bit digitization of output
Accuracy .1% of full scale (10 mv)

(2) Multiplier Electrometer (cont.)

Time Constant <.01 secs

Comparator at 10-15 μamps for range selection

Provision for comparator (with latch) at 25 μamps if multiplier protection should be necessary.

(3) Counter

Rate: $\geq 1 \times 10^8$ cts/sec (periodic)
5×10^7 cts/sec (random)

Dead Time Correction: $\leq$20% at 2×10^7 cts/sec

Discriminator Level:

Commandable 4 levels: TBS

Linear Capacity: 2^{24} (1.68×10^7)

Compression: Pseudo log
4 bit exponent
9 bit mantissa

14 September, 1978
GRC

GALILEO NMS
DESIGN NOTE

Data Handling

At the Galileo NMS engineering meeting on 30 August, 1978 a brief discussion was held regarding the method of telemetering housekeeping data in the general context of ease of data handling. The general problem of data recognition has been considered further and this brief note is intended to show that the present design provides for reasonable ease in data handling.

Interpretation of the information available indicates that the spacecraft minor frame is as shown in Figure 1, with NMS assigned 8 pair of contiguous 8 bit words equally spaced in the minor frame as typified by the shaded boxes. Thus NMS has one 16 bit word each 0.5 seconds. 14 of these bits are used to telemeter the main sensor output, 4 bit exponent, 9 bit mantissa, and 1 bit detector identification in the case of counter output, and for the grid electrometer, 12 bits of output, 1 bit of detector identification and 1 bit not used. This leaves two bits of each 16 bit word available for telemetering Multiplier current (I_m) and housekeeping data. Half of these will be used for I_m and the other half for the other housekeeping functions. This is illustrated in Figure 2.

The last two bits of each of the first four NMS words in a minor frame are used to telemeter the value of an I_m taken during the previous minor frame and the two bits of the second four words telemeter a housekeeping function. A 32 channel housekeeping multiplexer has been selected so the housekeeping word pattern repeats each 128 seconds.

The state of the 13 bit counter provides the information required to unambiguously identify the bits which comprise the 16 bit output word with which the counter state is associated. The least significant bits are driving the analog and digital multiplexers.

As the 3 least significant bits cycle through 0 to 7 the housekeeping bit pattern is identified.

0 Bits 1 & 2 of I_m

1 Bit 3 & 4 of I_m

2 Bits 5 & 6 of I_m

3 Bits 7 & 8 of I_m

4 Bits 1 & 2 of HSK6

5 Bits 3 & 4 of HSK6

6 Bits 5 & 6 of HSK6

7 Bits 7 & 8 of HSK6

0 Bits 1 & 2 of I_m

etc.

As the next four bits of the 13 bit counter cycle from 0 - 31, the multiplexer state is identified.

0	MPX 1
1	2
2	3
3	4
.	.
.	.
.	.
.	.
.	.
31	32
0	1
1	2
	etc.

The entire 13 bit word through a look-up table equivalent to the instrument ROM identifys the mass being sampled, ionization energy and whether or not a tune check is on-going. A small unavoidable complication exists in that the mass associated with a given I_m reading was identified earlier at the time its digitized value was shifted in to the readout register. That is to say a ROM bit comes true to indicate an I_m reading and the mass bits associated with that ROM interval identify the mass. The digitized I_m value will be shifted into a register to be read out during the next minor frame. For data display this mass number must be noted and stored for output during the next minor frame with the appropriate I_m bits.

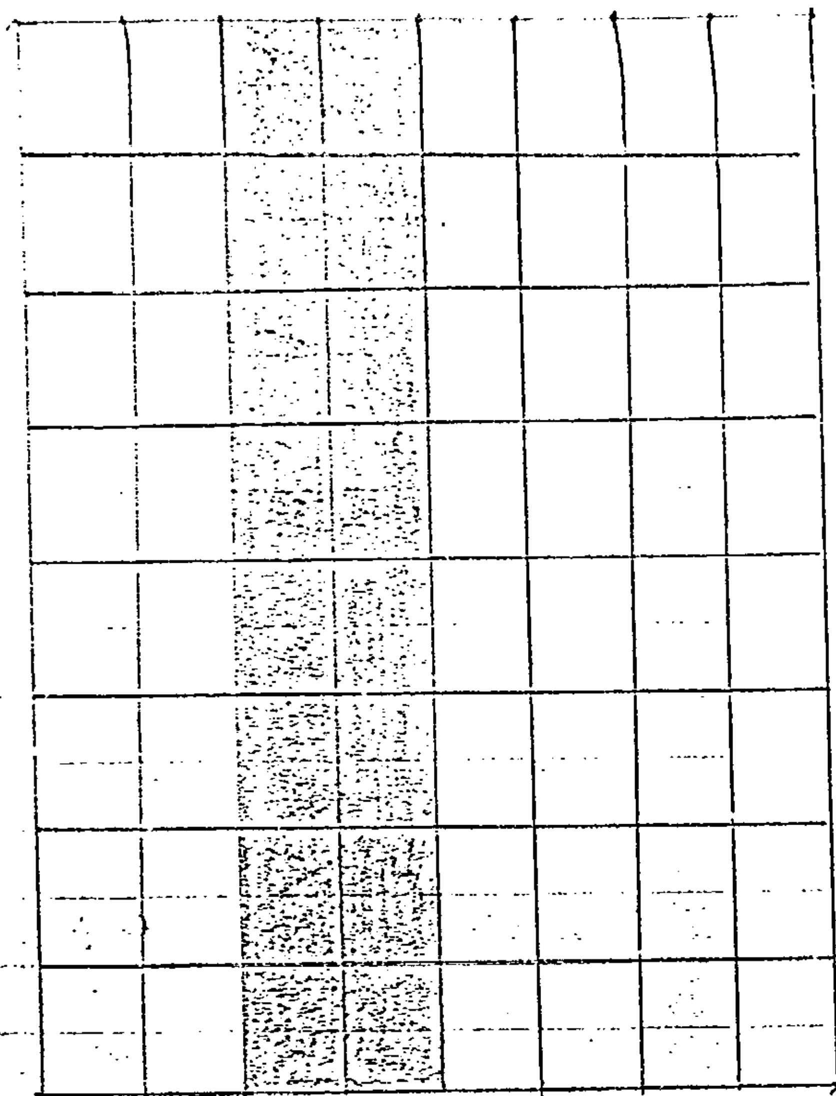
Thus the state of the 13 bit counter and a replica of the instrument ROM unambiguously identify each output bit. On the ground with GSE the state of the counter and the ROM are continuously available. On the spacecraft without GSE the 13 bit counter and a replica of the ROM must be part of the computer. At turn on and reset the computer based 13 bit counter must be reset and subsequently count either bits or words to track the instrument counter. The output addresses the computer based ROM to track the instrument configuration. Once each 128 seconds the state of the instrument 13 bit counter is telemetered for confirmation and resynchronization as necessary. If, as is probable, the instrument reset is tied to the S/C minor frame counter, then resynchronization information is available each 4 seconds since the state of the 13 bit counter equals 8 times the minor frame counter less the phase difference.

At turn-on 64 bits have been set aside to provide a one-time command readback and synchronization signal. However, this data would not be assimilated until after the first tune checks were completed so there could be some difficulty at turn-on. This problem is eliminated if the S/C frame counter could be used to establish synchronization before turn on or more correctly "reset." It seems very likely (or at least correct) that the S/C initialize signal to NMS will have a fixed and known relationship to the TM so that the problem of initial synchronization is eliminated.

Other than the potential problem of initial synchronization, the present design seems to fulfill reasonable requirements for ease of data handling and display. Software specialists should review the design for concurrence.

14 Sept 1998
GR

Spacecraft Minor Frame



8×8×8 bits = 512 bits
at 128 bps 4 secs

Line Period 0.5 secs
Minor frame Period 4.0 secs

NMS - 16 bits / 0.5 secs
14 used for Main Data
2 used for Invalid + Hskg.

Figure 1

Galileo NMS
BIT USAGE

15 Sept. 1978
GRC

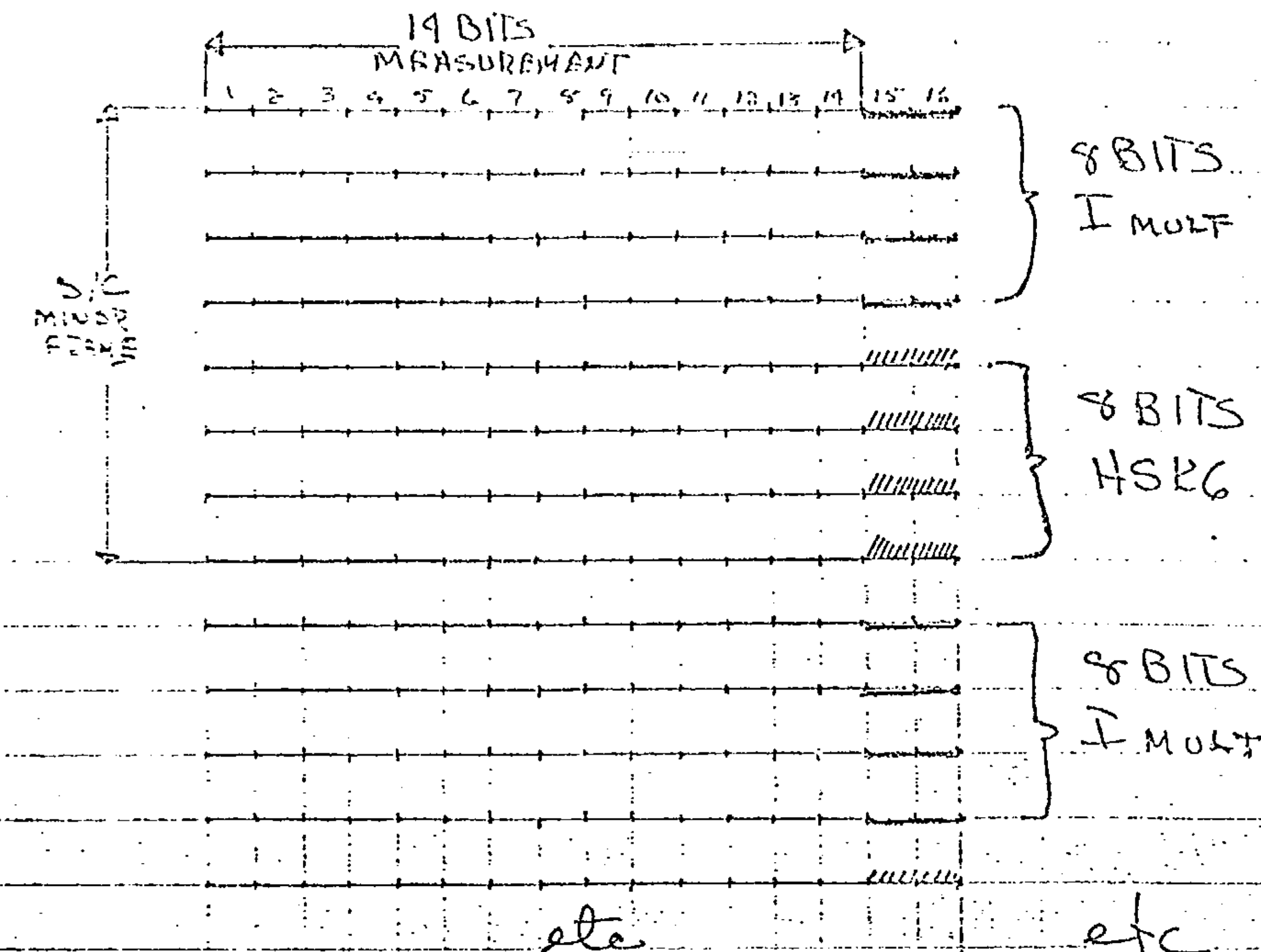


Figure 2

Notes from Galileo Probe NMS Meeting with ARC/HAC

September 14, 1978

Personnel Present:

H. Niemann, GSFC
J. Cooley, GSFC
[illegible], HAC
[illegible], ARC
[illegible], ARC

Purpose:

This meeting was held for the purpose of discussing the electrical and mechanical interface to the Probe.

Discussion:

Ion Pump - Only one analog pump voltage, pump current or temperature monitor line is desired. The three functions could be multiplexed.

Calibrate - A calibrate mode is being planned to enable a look at background prior to blackout during entry.

Commands - The pump power ON and pump power OFF commands will be provided by the spacecraft.

Power - Forty watts of power is allocated for instrument heaters.

Radiation Meeting at GSFC - ARC desires that GSFC send parts lists and mechanical drawings to ARC prior to the radiation meeting at GSFC in October so the radiation contractor can review them i.e., MRC people. There will be a discussion about type of components and how affected by radiation during the meeting.

Allocation of Words - There will be 64 words per minor frame and 16 minor frames per major frame. No NMS word assignments have yet been made.

G-Switch - A G switch will be provided to start the measurement sequence at ≈ 0.1 bar.

Bit rate change - The bit rate will be 128 bits/second to 10 or 15 bar and then switched (reduced) to 64 bits per second. The lower bit rate is desired to prevent dropout of communications with transmission frequencies used. The switch to 64 bits/second will probably change the bit format. The question then arose if a bit change signal was needed or can a change be derived from the signal. Finally, do we need a format readout status?

Dual Readout Capability - There will be two readout capabilities provided, 1024 bits per second and 512 bits per second, for ground checkout and fast speed readout.* A preference toward the 1024 bits per second rate was indicated. GSFC is to determine if they want the 1024 bit rate readout status. ARC will assume that GSFC does not want the 1024 unless notified to the contrary. It was indicated that the 1024 bit rate readout status may not be necessary if the read envelope is available. *(during cruise).

The capability would include the ability to operate six instruments at 1024 at one time or six instruments one at a time.

Descent Sequence -
The spacecraft signal sequence will be as follows:

a) g-switch operates at 0.1 bar
b) timer to power on bus
c) arm pyrotechnics

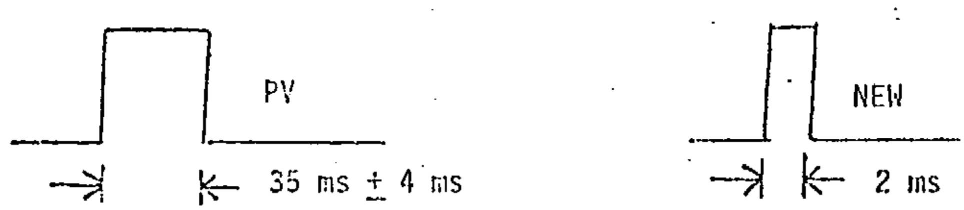
Fourteen volts will be provided for the pyrotechnics. When the 14 volts are made available, the instrument will distribute such voltage to its pyrotechnics.

The question arose as to the possible effects of a shorted pyro on the spacecraft battery. Some protective circuit may have to be designed into the circuit.

The GSFC Galileo Probe NMS has 14 pyrotechnics. Five amps will be provided by the spacecraft for pyro operation.

A question that needs to be looked into is the phasing of the instrument pyrotechnic firings and the s/c pyro firings. HAC does not want the instrument and spacecraft pyros fired at the same time.

Command Data - HAC has offered a new command envelope in lieu of the pioneer venus envelope previously considered.



GSFC needs to comment on the new envelope. T. Wong, ARC, does not like the new envelope.

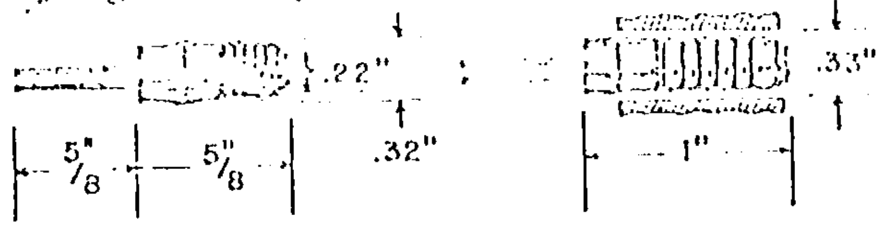
Input Buffers - The input buffers have been OK'd for radiation with 10×10^5 rads Si fluence level, but a change to the buffer will be required in the clock lines. In the clock lines, there is a spike following the pulse which will be compensated for by adding a circuit to the buffer. The read, 38 KHz, lines are OK and require no compensation for radiation.

Action Items:

- Send T. Wong (ARC) a copy of the report on KOVAR hybrid circuit can buckling
- Look at the s/c battery location with relation to our instrument. It is presently in close proximity to the NMS. HAC will also look at this.
- HAC will look at the differential pressures across the NMS inlet/outlet. They have indicated that the outlet could be run to the outside of the Probe.
- Copy of #1 mechanical layout for the NMS was given to HAC. They are to review it and comment and forward comments to GSFC.

Product Data - SEPT. 14/78

(TYPE) (BELLOWS ACTUATOR)



WIRE LEADS:	0.040-in. diameter Kovar pins
INSULATED SECTION:	None
BASE SECTION:	5/8-in.
CASE:	Brass (5 convolutions)
SEAL:	Kovar-glass; hermetic soldered type
BRIDGE RESISTANCE:	4-5 ohms; wire type
IGNITION:	Lead styphnate type
DELAY TIME:	-
MAIN CHARGE:	(Propellant) LMNR/black powder type

TYPICAL PERFORMANCE DATA

These data should not be used for specification. They are based on information developed in design tests, background comparisons, and moderate production runs. Values listed are average, and extreme limits cannot be guaranteed. Applications that require high reliability or performance under severe environmental conditions, or where the use is new, may require special modification or testing.

FIRING CURRENT (see Section 4.6)
- Test current (suggested max.) — 10 ma.
- MNFC - Max. nonfire (safety design, destructive) — 50 ma., one 30-sec. pulse
- MFC - Min. fire (borderline, not recommended) — 0.3 amp.
- RFC - Recommended (all-fire) — 1.0 amp.

IGNITION TIME					
- Amp. (d.c.)	0.3	0.6	1.0	1.5	2.0
- Time (milliseconds)	3.1	1.1	0.6	0.4	0.35

HIGH TEMPERATURE - Functioned normally after storage at:			
(Time:	1 hr.	30 days	3 yr.
(Temp. °F.:	-250	-160	-70

LOW TEMPERATURE (see Section 5.4) - Functioned normally at: -80°F.

HIGH ALTITUDE (see Section 5.1) - Functioned normally at 13-mm. Hg at -65°F.; excellent performance

MOISTURE RESISTANCE - Withstood MIL-STD-304 temperature and humidity test

RELIABILITY (see Section 7.2) - 99.9%

OUTPUT (see Section 21.3) - Bellows expands 3/8 in. to a stop holding against 25-lb. spring load test fixture #17

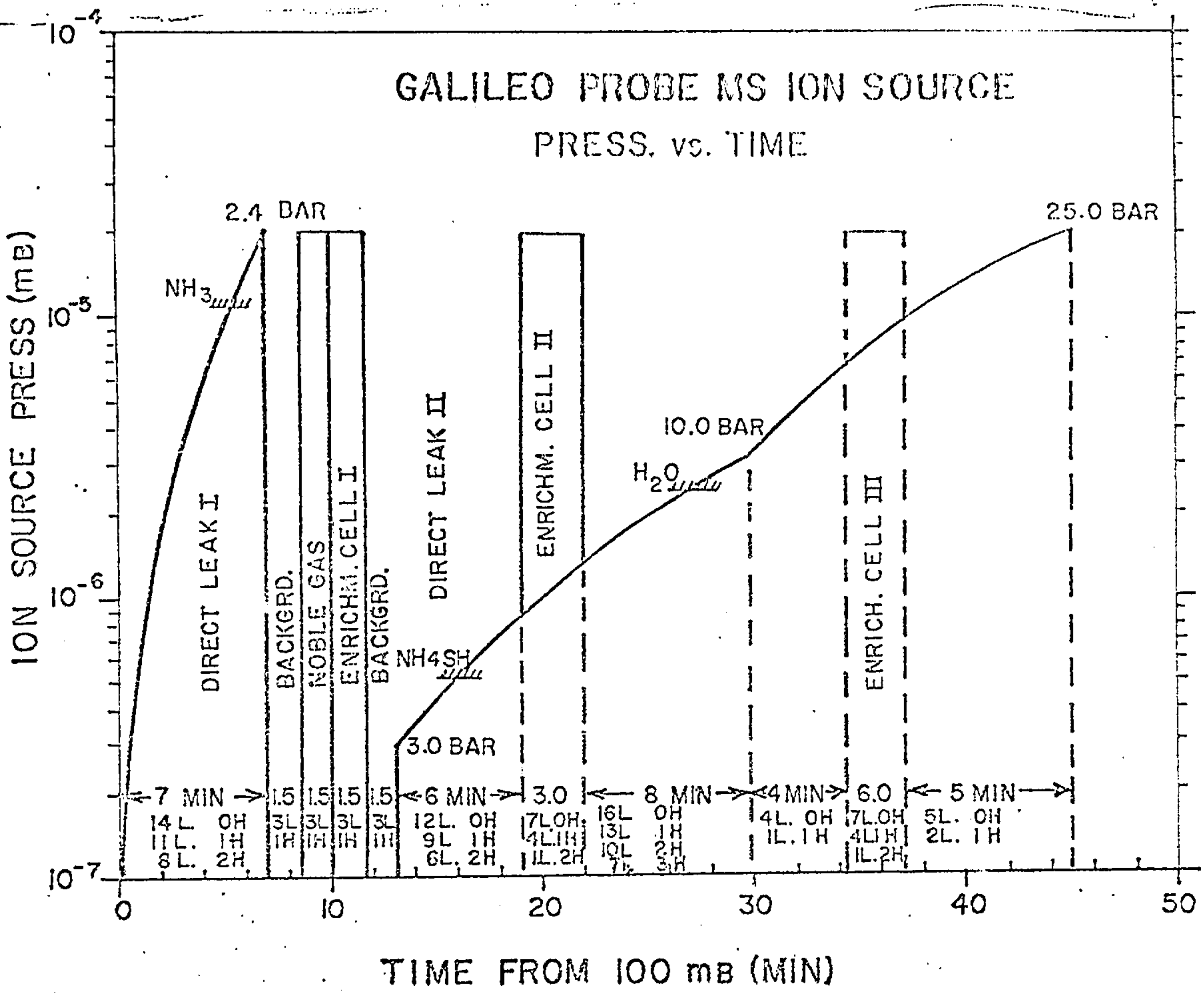
TYPICAL USES: Nonexplosive actuator for release mechanisms, safe and arm mechanisms switches, rotors

REFERENCES:

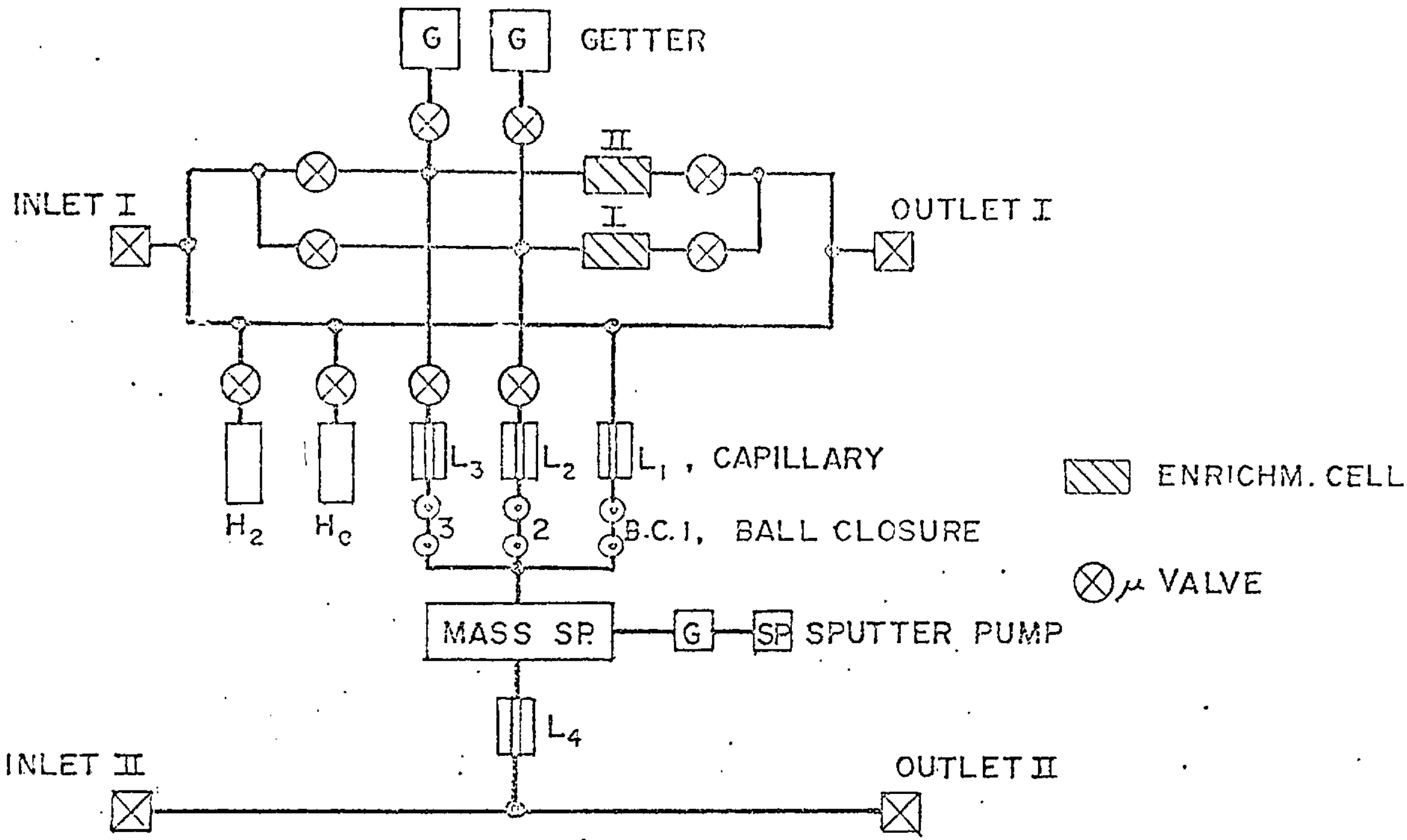
(SQUIB)
BELLOWS
ACTUATOR, BASE
SHEET: HD-845

DATE: 3-7-65
IBCHS

Sections referred to are in
HERCULES HANDBOOK OF INITIATORS AND ACTUATORS


GALILEO PROBE MS ION SOURCE
PRESS. vs. TIME
ION SOURCE PRESS (mB)
TIME FROM 100 mB (MIN)
2.4 BAR
3.0 BAR
10.0 BAR
25.0 BAR
NH3
NH4SH
H2O
DIRECT LEAK I
BACKGRD.
NOBLE GAS
ENRICHM. CELL I
BACKGRD.
DIRECT LEAK II
ENRICHM. CELL II
ENRICH. CELL III
7 MIN
6 MIN
3.0
8 MIN
4 MIN
6.0
5 MIN
14 L. OH
11 L. 1H
8 L. 2H
12L. OH
9L 1H
6L. 2H
4L. OH
1L. 1H
5L. OH
2L. 1H

GALILEO PROBE M.S.
BLOCK DIAGRAM



[illegible] ON [illegible] VALVES

[illegible] — 14VDC @ 70°F REQUIRES 1.5 AMP PEAK.
- NOMINAL 14VDC, 2 TO 5ms PULSE
LATCHING VALVE IS BIDIRECTIONAL LATCHING IN THE OPEN & CLOSED POSITIONS OF THE VALVE.
VALVE IS ACTUATED FROM OPEN TO CLOSED POSITION OR VICE VERSA BY REVERSAL OF THE VOLTAGE POLARITY ON TWO ELECTRICAL LEADS.

NO ELECTRICAL POWER IS REQUIRED FOR HOLDING THE VALVE IN THE OPEN OR CLOSED POSITION (PRESENT LATCHING)

BODY OF VALVE GROUNDED THRU ADAPTER PLATE.
APPLY POSITIVE VOLTAGE PULSE TO POSITIVE TERMINAL OPENS VALVE. APPLYING POSITIVE VOLTAGE PULSE TO NEGATIVE TERMINAL OR NEGATIVE VOLTAGE PULSE TO POSITIVE TERMINAL

[illegible]

[illegible] ARMATURE (2)

[illegible] WHEN

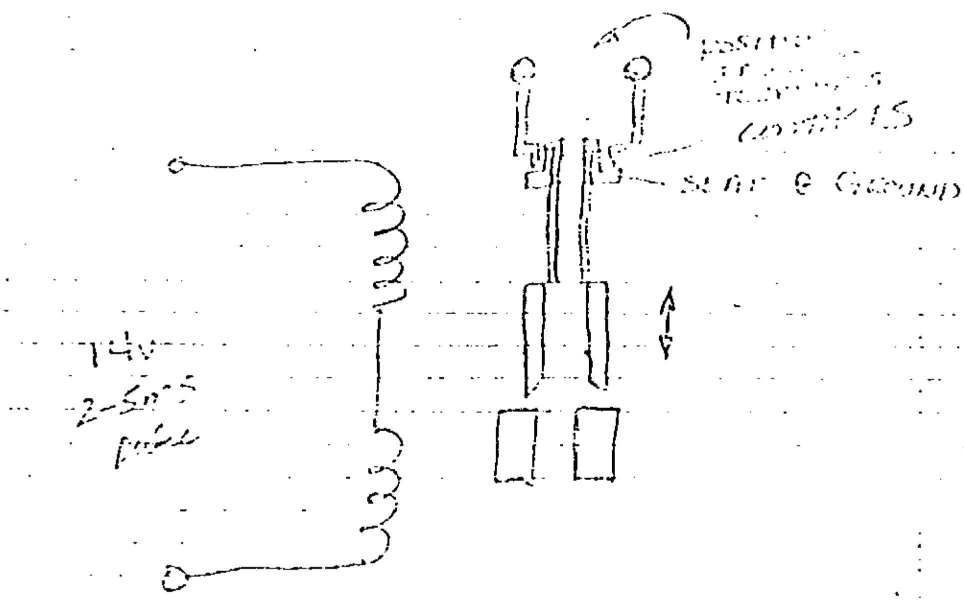
[illegible] CLOSED AND

[illegible] CIRCUIT TO

[illegible] AND TO

[illegible] WHEN VALVE

IS OPEN.



THE UNIVERSITY OF MICHIGAN
ANN ARBOR

SPACE PHYSICS RESEARCH LABORATORY

October 5,1978

M E M O R A N D U M

MEMO TO: Galileo File

FROM: Bill Potter

SUBJECT: Some thoughts on High-speed Counters and Floating-point Representation of Data

Two aspects of the current Galileo concept for pulse counting and encoding the counts for T/M leave me with a feeling that our design is less than optimum. The Galileo design is probably too far committed to make a significant change, but I would like to set down these thoughts for future projects.

These "uneasy" aspects are:

1. The first few stages of the ion counter require a high speed, high power implementation. Thus the stages which produce the least significant data are the most costly.

2. Under Poisson statistics, the standard deviation (σ) of the count is equal to the square root of the count. This means that, in general, only the high order half of the bits required to express a count are statistically significant. Thus the number of significant bits is a function of the count itself. Further, it means that the few lowest-order bits are almost never statistically significant.

SUBJECT: Reading out High Speed Counters

Reading out a counter stage requires a Count Enable function associated with the fastest stage to be read, and a clear function associated with all stages to be read. If the high speed portion of a counter is implemented with a different logic family from the rest of the system, level changers are required for these two signals, in addition to the level changers that are required to sense the counter content. Thus we pay a penalty in weight and power just for reading these bits that is in addition to the cost of the high speed counter itself.

In general, a "bare bones" divide-by-two circuit, without any reset or input gating, can achieve a faster count rate with less power consumption than an equivalent counter with these additional components. I don't know if this fact is reflected in commercially available IC's or not.

The conclusion to be reached is that, while we must have these high-speed counter stages to achieve adaquate pulse resolution, we should not read out their contents unless there is a scientific need to measure very small count rates (> 100 counts, for example).

When telemetry is expensive, the optimum number of bits to telemeter is dependent on the magnitude of the count itself, and hence is data dependent.

SUBJECT: Truncation Error

Whenever some low order bits are dropped, a small but systematic truncation error is introduced. This error is easily corrected for in data analysis. However, in the case where we do not clear the low order bits of the counter that we do not read out, the count which is left over from one integration period is added to the next, and any statistical bias is cancelled out. No other correction for truncation error should be included in data analysis.

SUBJECT: Variable-Length Mantissa for Floating Point Encoding

One can devise a variety of encoding schemes for floating point numbers where the total number of bits remains constant, but the allocation between exponent and mantissa varies with the magnitude of the count. It is relatively easy to devise such schemes where the number of bits in the mantissa is approximately equal to the standard deviation of the count, and which could be implemented with an on-board microprocessor. It's a little tricky to find one which can be impemented with hard logic and which will give a net reduction in weight and power. I haven't found one yet, but some of the schemes I have looked at show systematic bit patterns that suggest that a very simple implementation may be possible.

THE UNIVERSITY OF MICHIGAN

SPACE PHYSICS RESEARCH LAB.

October 12, 1978

MEMO TO: Galileo File

FROM: Bill Potter *Potter*

SUBJECT: Counter to Check Oscillator Frequency:

Conceptual Design

Requirements:

Read out a binary number into the housekeeping data stream from which the oscillator frequency can be deduced. The resolution in frequency readout must be equivalent to less than 1/8 AMU at the worst case (mass = 150 AMU). We can assume a priori that the oscillator never drifts more than 100Kc from nominal, so some high-order bits of the count may be discarded.

Accuracy Calculations:

The quadrapole equation is:

$$m = 0.1384\frac{V}{R_o^2 f^2}. \qquad (1)$$

If R_o = 0.5 cm..

$$m = 0.5536 \frac{V}{f^2} \qquad (2)$$

$$V = 1.8063\ f^2 m \qquad (3)$$

Where V = peak AC voltage, in volts

f = frequency, in MHZ

m = molecular mass, in AMU.

by partially differentiating Eq. 2:

$$\frac{\Delta m}{m} = -2 \frac{\Delta f}{f}$$

$$\Delta f = -\frac{f}{2m} \Delta m$$

If we let Δm = 1/8 AMU:

$$\Delta f = \frac{f}{16m}$$

We can now compute Table 1:

Table 1 Oscillator Parameters

m	f	V	Δf (MHz) to shift 1/8 AMV	
1	4.0	28.1	0.25	
5	4.0	144.5	0.05	
6	2.1	47.8	0.022	
50	2.1	414.2	0.0025	
53	1.2	137.8	0.0014	
150	1.2	390.2	0.0005	critical case
250	1.2	650.2	0.0003	

If we never sample masses greater than 150 AMU, the worst case is for mass 150, and indicates a resolution requirement of 500 Hz. Bits less significant than 500 Hz, therefore, may be discarded.

The simplest way to discard these bits is to use a count interval of 1/500 second, so we don't generate them in the first place. There seems to be no appropriate time base available; however. The next simplest way is to use a count interval of 1/2 sec, for which an appropriate signal is available, and prescale by a factor of 256, so that the number resulting in the counter is f/512

If we follow the pre-scaler with a counter whose bits we will read out, then f = 512 * count. We must read out 13 bits to determine frequencies up to 4 MHz. If, however, we are willing to assume a reasonable stability in the oscillator,

then we need not read out (or generate) some of the high order bits. Since the housekeeping data system is already set up to handle data in 8 - bit bytes, it would be good to read 8 bits of frequency data if possible. Dropping the 5 high order bits gives a redundancy of $\pm$ 131.072 N KHz, where N is an integer. Thus the frequency is given by

f = 512* count $\pm$ 131.072 * N Hz,

where N is an integer which must be determined from a priori knowledge of the frequency. N is 8 or 9 for the nominal 1.2 MHz frequency, 15 or 16 for the 2.1 MHz frequency, and 30 or 31 for the 4 MHz frequency.

If this ambiguity is not acceptable, the counter can easily be extended and an additional shift register added to read out the high order bits as another byte. This high order byte could be sampled less often than the low order byte.

3 pp
B Elero

Commanded Mass Re-Tuning on Galileo-NMS

The mass selection system for the Galileo-NMS will use three RF frequencies to reduce the amplitude range required to cover the desired mass range. Assuming the worst of all circumstances, with no knowledge of the system generating the rod voltages, it is reasonable to call for independently commandable gain and offset trim capability for the RF amplitude transfer function and for the DC amplitude transfer function for each of the three frequencies. This results in a requirement for 36 bits of command functions ((gain + offset) x (RF + DC) x (3 frequencies) x (3 bits/function) = 2 x 2 x 3 x 3 = 36).

Analysis of the system suggests some areas where the number of functions may be reduced. The only likely source of error in the control system that can be corrected by changing the offset in the transfer functions is the forward voltage drop of the rectifier diodes in the oscillator feedback loop. This value should not be frequency dependent, so one value of offset correction should suffice for all three RF frequency ranges and no offset adjustment should be required on the DC function.

There are two kinds of changes that can be corrected by providing gain control for the RF amplitude: frequency drift and loop gain drift. Clearly, frequency drift must be assumed independent for the three frequencies being generated. Gain drift may or may not be frequency-related. Since the system must provide three different gains (Amplitude vs. Mass), the opportunity exists for independent drifts. Independent gain drift is unlikely, however, since the separate elements involved in setting the gains are large-value resistors in series with small-resistive-value saturated switching elements. The switching elements are all part of the same integrated circuit and may be assumed to

show comparible drifts. Independent RF gain control remains a requirement on the basis of the expected form of frequency drift.

There are two purposes in providing gain control for the DC amplitude: changes in the loop gain of the Rod DC Amplifier, and tracking of changes made in RF amplitude function. Gain of the DC amplifier is not expected to be a function of frequency, for the same reasons stated above for RF gain. Where RF gain correction is applied to compensate for RF gain drift, the resulting RF amplitude will be the originally-set value and no adjustment of DC gain will be necessary. Where RF gain correction is applied to compensate for frequency drift the DC gain will have to be adjusted correspondingly to maintain the correct RF - to - DC ratio. On this basis, as many sets of gain controls must be provided for DC as exist for RF.

Looking at the stability requirements on the mass selection parameters, it may calculated that

$$\frac{\Delta M}{M} = \frac{\Delta V_{RF}}{V_{RF}} + \frac{Z\Delta F_{RF}}{F_{RF}} .$$

If

$$\frac{\Delta M}{M} = \pm \frac{1/10}{150} ,$$

and equal percent drifts are assigned for amplitude and frequency, then

$$\frac{\Delta V_{RF}}{V_{RF}} = \frac{\Delta F_{RF}}{F_{RF}} = \pm\ 0.02\% \text{ of the 150 AMU values.}$$

Assigning half the V_{RF} error to the oscillator control loop and half to the D/A converter providing the analog reference for the loop, it can be seen that the D/A must be good to $\pm 1 \times 2^{-13}$ (i.e. an "honest" 12-bit D/A), and the allowable control loop gain drift is ± 10 ppm/°C assuming a 100-degree temperature range. Looking now at the 6-50 AMU portion of the mass range

$$\frac{\Delta M}{M} = \pm \frac{1/10}{50} ,$$

and $$\frac{\Delta V_{RF}}{V_{RF}} \cdot \frac{\Delta F_{RF}}{F_{RF}} = \pm .06\% \text{ of the 50 AMU values.}$$

Since the D/A is already specified at ± .01% , the control loop drift may be relaxed to ± 0.05% over temperature, or ± 50 ppm/°C. Similarly, for the 0-5 AMU range

$$\frac{\Delta V_{RF}}{V_{RF}} \cdot \frac{\Delta F_{RF}}{F_{RF}} = \pm 0.6\% ,$$

and the gain is ± 0.59% over temperature, or ± 590 ppm/°C. A qualitative assessment of this suggests that if the control loop and frequency-determining circuitry built with enough accuracy to meet the 50 and 150 AMU requirements, there should be no significant gain-related drifts on the 5 AMU range and the commandable gain corrections for that range may safely be deleted.

The result of all this is the suggestion that the original requirement of individual gain and offset controls for RF and for DC at each of the three frequencies (comprising a total of 36 command bits) can be reduced to a requirement for a single RF offset control, RF gain control for the middle and high masses, no DC offset control, and DC gain control for the middle and high masses (comprising a total of 15 bits) with no practical loss in functionality.

THE UNIVERSITY OF MICHIGAN

ANN ARBOR

SPACE PHYSICS RESEARCH LABORATORY

October 18, 1978

M E M O R A N D U M

To: Stan W[illegible]
[illegible]

From: B. P. Elero, Jr.
[illegible]

SUBJECT: Meeting at General Electric/Space Systems

On Friday, October 13, 1978, a visit was made to General Electric Space Division in Philadelphia by members of the Space Physics Research Laboratory. The purpose of this meeting was to discuss the possibility of GE supplying several high quality flight multi-layer printed circuit boards.

Our first course of action was to meet with John Billings, manager of Product Design & Standards, the department responsible for overseeing the design and layout of the boards. Our first task was to get a rough idea of the number of multi-layer boards that we would need for the Galileo Probe Neutral Mass Spectrometer electronics systems. We used a rough estimate for the number of hybrid circuits that we will be using in conjunction with these multilayer boards. From this analysis we decided initially we would be using from one to three different types of multi-layer board.

We were quite impressed with the layout facilities at GE and apparently they are qualified to supply multi-layer boards since they are in the process of completing a program for the Air Force which used well over 200 multi-layer boards. After GE does the layout of these boards they choose a vendor that satisfies their stringent quality assurance program. They are willing to conform to MIL-P-55640A, the military specification for multi-layer (plated through holes) boards in conjunction with their own specification GE-S30079.

It is my intention to collect the necessary information to send to GE so they will be able to generate a quote for supplying Space Physics with multi-layer printed circuit boards.

Cordially,

Bernie Elero

BPE:slj

5. CONCLUSIONS

As of 30 September, 1978 the conceptual design of the Jupiter Probe Spectrometer electronic system was tentatively complete. Block diagrams and circuit diagrams presented in Section 2 have been generated and very preliminary parts lists have been tabulated. An assessment of the design indicates no major technical problems and that the final detailed design should be completed by late December, 1978.

Key problem areas appear to be:

(1) Schedule; particularly in providing the hybrid circuit vendor final drawings in time to allow the vendor to meet required delivery dates. Additional spacecraft interface information is required before many of the circuits can be released for fabrication.

(2) The question of weight of the electronics is impossible to assess accurately at this state and there exists some concern that the stringent weight limitation can be met with the existing design. This issue should be resolvable when the design is complete and a rigorous weight estimate can be made.

(3) Radiation hardness of certain devices otherwise suitable for the electronics. This problem appears tractable, but further consideration must be given to the selection of device types.

The results of the design effort to date, in summary, shows that an electronics system appropriate to the Jupiter probe mission can be realized drawing upon well tested concepts from previous spaceflight experience in mass spectrometry. A sensitivity to schedule, weight and radiation integrity is indicated as we proceed toward the final design and its release for fabrication.